MODERN LIFE SCIENCE

Teacher's Guide

FITZPATRICK • HOLE

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MODERN LIFE SCIENCE
TEACHER'S GUIDE

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PART ONE: Introduction

GENERAL AIMS AND PURPOSES

As the ideas and products developed by scientists continue to affect our lives to a greater and greater extent, it becomes increasingly important that each of us expand our understandings. Thus, the study of the nature of science, together with the facts, conclusions, and generalizations developed by scientists is an appropriate part of general education.

Modern Life Science is planned to introduce beginning students of science to the nature of biology and to some of the facts and major ideas advanced in this field.

The study of living things is approached from the ecological point of view, which concerns interrelationships between organisms and their environments. This theme was selected so that it would be possible to guide the beginning student from his familiar surroundings toward a consideration of some of the less familiar aspects of biological systems. At the same time, the way in which biologists work in their attempts to gain more knowledge about interactions between living and nonliving factors in an environment is emphasized. And, so that students may become personally involved in some scientific endeavors, a great variety of laboratory activities are provided.

In recognition of the tremendous, growing body of biological knowledge that now exists, an attempt has been made to limit the text and laboratory presentations to facts, ideas, and activities needed to support the ecological theme. However, many modern ideas about cell structures and functions and some of the newer ideas related to microstructure and the chemical basis of life have been included.

It is hoped that the text materials presented in an ecological framework and supported by a variety of laboratory experiences will serve to stimulate the student's interest and motivate him to extend his study of science as he continues his formal education and in his adult life.

ORGANIZATION OF THE TEXT

The text is divided into four blocks of subject matter. Each block is designed to extend the ecological theme. Thus, the chapters and laboratory activities of Block I concern the nature of organisms and their environments. Block II deals with populations of living things in natural communities. Block III describes man and his role in natural communities, while Block IV presents certain special problems such as population increase, selection, heredity, and the wise use of biological resources.

Each block is introduced with a short discussion emphasizing the historical setting of the topics developed within the block. (See the introduction to Block I, page 3.) At the end of each block there is an extensive summary of the major ideas presented in the block. (See the summary of Block I, pages 136-138.) These can be used to remind students "where they have been," and at the same time provide a setting for the introduction of the next group of chapters.

The chapters within a block develop the block theme in a sequential manner. For example, Block I, *The Simple and the Complex*, presents the basic material concerning the nature of organisms and their environments. Chapter 1 of this block deals with the broad topic of environmental factors and makes use of familiar organisms to introduce the idea of living things within an environment.

Chapter 2 introduces some of the details related to the chemical nature of living things as well as of the environmental factors, and emphasizes the chemical and energy needs of the living substance.

Chapter 3 concerns the structures and functions of cells, which are built of the chemical materials obtained from the environment, and form the basic building blocks of organisms.

Chapter 4 follows with a discussion of how the cells within an organism are organized into tissues, organs, and organ systems, and how these structures may be adapted for special functions of importance to organisms living in particular environments.

Chapter 5 emphasizes the great variety of plants and animals that exist, and "sets the stage" for a study of biological communities which consist of populations of various species living and interacting within a common environment.

This block ends with a collection of *Laboratory Investigations* which are closely related to the topics presented in the preceding chapters and can be used to supplement them. This section also includes instructions for a detailed study of a particular biological community which can be used to bridge Blocks I and II in that the study makes use of ideas and techniques presented in Block I, but at the same time introduces some of the major ideas that are discussed in Block II.

The text materials are written in a clear and simple manner. Words of primary importance appear in bold face italics and are followed by the phonetic pronunciation. In most cases, such words are used again in later sections of the text. Other key words appear in italics. The captions for the illustrations often ask a question or otherwise suggest an activity on the part of the reader. These are used to help the reader relate ideas presented in the text to other situations and can serve as topics to be developed in class discussions.

Within the chapters there are instructions for laboratory demonstrations and activities. In each case, these suggestions are designed to supplement the material of the text.

At the end of each chapter there are groups of questions to aid the reader in reviewing the text material. The *Word Meanings* section (see page 19) reviews key words by use of multiple choice or matching questions. Sometimes, the matching sections appear in two parts. It should be noted that in such cases the parts do not differ in difficulty. The sections were divided to shorten the lists of items to be matched.

The *Self Test* (see page 19) deals with the facts of the chapter. The items usually take the form of true-false questions, and in the case of the false items, the reader is instructed to reword the statements and make them true.

The *Discussion Questions* (see page 20) emphasize broader ideas and interrelationships, and can be used in oral discussion or in written assignments.

There also is a section called *Things To Do* (see page 21) which consists of brief suggestions for activities related to specific ideas discussed in the chapter. *Reading Further* (see page 21) lists reference books of value to students who are interested in learning more about certain topics.

THE LABORATORY PROGRAM

Throughout the text there are suggestions for laboratory activities which can be used to stimulate student interest and expand understandings of ideas presented in the text. These laboratory suggestions take a variety of forms. Some concern simple demonstrations. Others involve qualitative or quantitative observations to be made in the field or in the classroom. Among these are a number of investigations that are left "open-ended" in the hope that interested students will want to continue working on their own.

Probably there are more laboratory activities provided than can be completed by any one class. This makes it possible for a teacher to choose a group of experiences that can be accomplished with available materials and will match the needs of a particular student group. Thus, one set of activities can be selected for a group with average ability, while another set can serve a group of more able students.

It should be noted that whenever possible, the laboratory suggestions involve simple and easily available supplies and equipment. Also note that *living* materials are used frequently. Moreover, it must be recognized that many of the activities cannot be performed without adequate tools, including laboratory microscopes, hand lenses, and dissecting equipment.

Chapter 1, which introduces the ecological theme, can be used to illustrate some of the types of laboratory suggestions that have been included in the text. In connection with a discussion of the pond environment, there are specific instructions (see page 11) for collecting a pond culture in the field, maintaining it in the classroom, and observing the organisms that may be present. Such an activity might serve as the basis for a class field trip to collect pond samples, followed by the establishment of a number of small classroom aquariums to be used for investigations later on. Each student might want to establish and maintain such a pond culture, or you may decide to divide the class into small groups of two or three students each. If groups are formed, make sure that each student is assigned a specific task. For example, one might clean the aquarium and add the sand and water. Another student might add the plants, while a third looks after the animals.

This exercise is typical of many others. Note that the materials used are for the most part of a simple type, and that the instructions provide the necessary background information for the student. Note also that *Analysis Questions* are provided at the conclusion of each activity. These are planned to stimulate student thought and to aid the student in relating his laboratory experience to the materials discussed in the text.

After a laboratory activity has been completed, it is important that students have an opportunity to discuss their observations and ask questions. Often it will be necessary to remind students of the relationship between an activity and the study at hand. The *Analysis Questions* can be used as points of departure for such a discussion.

Chapter 1 also introduces the nature of science, biology, and the biologist. The point is made that observations depend upon the senses of the observer and that these senses are limited. At this time suggestions for a demonstration of sense limitations are included. (See page 15.) Such a demonstration can be performed by all the students. In other cases, you may want one student or a small group to perform the demonstration for the class.

Following the section in Chapter 1 which discusses scientific experiments, instructions are included for an investigation of blood vessel contraction in an earthworm. Note that in addition to detailed instructions, a sample data sheet is provided which can be copied and used to record observations as they are made.

Following such an investigation, it will be important to give students an opportunity to discuss their results. Often they will need help in interpreting the results, and you may want them to compile class results and calculate averages from time to time. In this way, you can emphasize the importance of having individual observations confirmed by others before accepting the observations as valid.

Note that the earthworm blood vessel contraction investigation is left with an "open-end." The section *Planning an Experiment of Your Own* (see page 18) is designed for students who are interested in going further. They are encouraged to investigate the problem in greater depth and to plan their own procedures. In such cases, however, the student is advised to have the teacher check these plans before they are carried out. Insist that student plans include provision for collecting and organizing data. You may also want the more able students to consider presenting their data in line or bar graph form whenever possible.

At the end of each block of chapters, there is a section called *Laboratory Investigations.* (See page 105.) Here are a number of additional suggestions for laboratory activities related to the topics presented in the chapters of the block. Also included are discussions of general procedures such as collecting, culturing, and preserving specimens, as well as detailed instructions for the use of such tools as the microscope and the Geiger counter.

Part III of the *Laboratory Investigations* for Block I (see page 130) presents instructions for a detailed study of a pond community. In this study students will gain experience in observing, collecting, culturing, and preserving specimens. They will also make use of many of the ideas and laboratory techniques discussed in the chapters of Block I. A similar study of a land community is included in the *Laboratory Investigations* for Block II.

It can be anticipated that students will sometimes obtain experimental results different from those expected, or will obtain no results at all. The important thing is that they understand that such is the nature of experimental work. If the results do differ from the expected, you may want the students to repeat their observations to see if the same results can be obtained a second time, or a discussion of possible sources of error may be appropriate. Other times, alternate ways of making necessary observations may be discovered, or ways of improving upon the instructions may be discussed.

THE TEACHER'S GUIDE

The Teacher's Guide is divided into three major sections—an *Introduction,* of which this is part, a *Chapter Guide and Answer Key,* and an *Appendix.*

In the *Chapter Guide and Answer Key* the contents of each chapter is outlined in a chart entitled *The Chapter at a Glance.* Included in this chart is a list of the major ideas to be emphasized and a list of the laboratory activities, investigations, and *Things To Do* that are related to each chapter. Following *The Chapter at a Glance,* there is a list of motion picture films which might be used to supplement various major ideas. The *Overview and Rationale* section discusses the chapter as a whole and the way in which the chapter is developed to support the ecological theme.

It will be important for the teacher to remind the students, from time to time, how a particular chapter or series of chapters fits into the development of the ecological theme. Otherwise students may become lost in the details and activities of a chapter and fail to note "where they have been" in the text, "where they are going," and how a particular chapter fits into the scheme of things. The *Overview and Rationale* sections may be employed to orient student thinking about such problems.

The Chapter at a Glance chart provides information concerning the chapter contents in a condensed form. This should be helpful to the teacher who is planning a schedule and deciding when to introduce various related films and laboratory activities, which in some cases appear in later sections of the text. The chart may also prove useful as a guide for review of the chapter and as a source of topics to be included in teacher-made tests.

Getting Started provides suggestions for ways of stimulating student interest in the study of a particular chapter. These often involve laboratory or field experiences related to chapter topics. The suggestions may also make use of the chapter *Things To Do* or a classroom discussion based upon "key questions" concerning an object or idea. In some cases suggestions for a way of developing the complete chapter are included.

In the *Chapter Notes* further background information is provided for the teacher. This information may be used to guide class discussions and to expand upon topics that students find of particular interest. Suggestions for ways of developing certain topics are discussed.

Laboratory Suggestions includes a statement of purpose for each activity. Also provided is a list of the materials needed and a discussion of the activity. In the discussion, ways of presenting the laboratory experience may be described. Instructions for obtaining necessary materials and organisms and for preparing various stains and solutions are included, as well as discussions of special techniques. Pitfalls to be avoided are discussed.

The answers to the laboratory activity *Analysis Questions* can be found here.

At the end of the guide for each chapter, you will find the answers to the end of chapter materials: *Word Meanings, Self Test,* and *Discussion Questions.* In the case of the *Self Test,* false items are discussed at length. Finally, a list of *Teacher References* is included. Note that this list is in addition to the list of references given at the end of each chapter in the student book. The addresses of the publishers are provided in the *Appendix.*

In the *Appendix* you will find a listing of all of the laboratory activities included in the text, together with a short description of each activity. The *Appendix* also provides a list of major pieces of equipment needed for the laboratory program and contains the names and addresses of suppliers of chemicals, equipment, materials, films, and reference books.

TESTS FOR MODERN LIFE SCIENCE

Evaluation of instruction has a very real function in any educational experience. It enables the teacher to discover what has been grasped by the students, as well as what has not been understood or what has been misinterpreted. It indicates the extent to which individuals are making progress, or failing to do so. Combined with student counseling it can be a powerful stimulant to learning.

The *Modern Life Science* materials include a battery of objective tests which may be described as follows:

Chapter Tests. There are 23 of these tests, which may be administered singly, or in any combination the teacher finds appropriate. Each of these tests includes a laboratory section dealing with the laboratory investigations related to the chapter content. In the event that the laboratory investigations have not been carried out, the teacher may direct the students to omit some or all of the laboratory items.

Block Tests. There are four of these tests corresponding to the four blocks in the textbook. Whereas the chapter tests concentrate upon facts and procedures, these block tests deal primarily with understanding of concepts, principles, methods of scientific investigation, and the application of what has been learned to the solution of individual and group problems.

It must be admitted, however, that paper and pencil tests have their limitations. They generally do not take into account changes in student behavior that can only be perceived through observation in the classroom, the laboratory, or the field, or gleaned from the results of interviews. For this reason, an *Inventory of Student Performance* has been prepared and included in this manual. It is suggested that the teacher examine this inventory with care, adapt it to the local situation by deletions and additions, and then have sufficient blanks prepared to record the performance of all students.

INVENTORY OF STUDENT PERFORMANCE

I. Student name ____________________

Age ______ Class ______ Starting date ______

Cumulative absence record ____________

Cumulative test record ______________

II. *Directions:* Indicate progressive performance as follows: *A*—to a very high degree; *B*–to a high degree; *C*–moderately or average; *D*–to a less than average degree; *E*–well below average. Note below that the semester is divided into four quarters (Q), and that entries should be made for each quarter. The items that follow have to do with performance, and with indications of attitude and interests.

1. Is the student orderly and attentive in class?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

2. Does the student voluntarily participate in class discussions?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

3. Is the student's class participation intelligent and to the point?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

4. Does the student exhibit an attentive and cooperative attitude in the course of field trips or field study?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

5. Does the student appear to understand the meanings of biological terms?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

6. Does the student maintain a notebook that is effective from the standpoint of records and use in review study?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

7. Does the student volunteer to participate in group activities and assignments?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

8. To what degree is participation in group activities effective?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

9. Does the student formulate intelligent hypotheses when confronted with problems?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

10. Does the student exhibit effectiveness in planning tests and experiments?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

11. Does the student make accurate observations and records?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

12. Does the student avoid "jumping to conclusions" in advance of the facts?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

13. Does the student exercise proper care of equipment?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

14. Does the student use biological apparatus (measuring, weighing, heating, cooling, etc.) effectively?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

15. Does the student use the compound microscope effectively?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

16. Is the student effective in using dissection instruments?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

17. Is the student capable of making good temporary mounts (slides) of biological materials?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

18. Is the student willing to assist when called upon to do so?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

19. Does the student participate in maintaining biological materials such as cultures?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

20. Does the student make use of available reference books?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

21. Does the student exhibit an interest in biological materials and phenomena outside of the classroom?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

22. Does the student maintain a hobby or interest in any way related to biology?

Q1 ..... Q2 ..... Q3 ..... Q4 .....

PART TWO—CHAPTER GUIDE AND ANSWER KEY

BLOCK I The Simple and the Complex

CHAPTER 1 Environment and Life

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction		Observation of miniature aquaria, see Getting Started, Chapter I (p. 3) Field Observations, Class Notes, Teacher's Guide (p. 3)
2. Field Observations	A great variety of living things exist all around us. Every living thing is surrounded by living and nonliving things and is affected by these factors.	Preserving Specimens, Lab Investigations (p. 111) Physical Factors of the Environment, Lab Investigations (p. 115) Things To Do, #1,2 (p. 21)
A. Features of the environment		
Living factors		
Nonliving factors		
B. Changes in the environment	The environment is constantly changing.	
Erosion		
Population numbers		
Seasonal changes		
3. A Pond Environment		A Pond Culture (p. 11) Use of the Microscope, Lab Investigations (p. 113) Collecting a Pond Culture, Lab Investigations (p. 109) Things To Do #4,5,6 (p. 21)
A. Adaptations to life in water	In order to survive, an organism must be adapted to the environment in which it lives.	
B. Aquatic animals		
C. Aquatic plants		
4. Environment and Survival	As the environment changes living things also change.	
A. Changes in a pond culture		
Population numbers		

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
5. The Study of Biology	Biology is the branch of science concerned with the study of living things.	Things To Do #3 (p. 21)
A. Biology, a growing science		Some Tests of Observations (p. 15)
Photosynthesis, an unsolved problem	Biologists are faced with many unsolved problems.	
Practical applications	The study of living things is of value to everyone.	
B. Methods of the biologist	Biologists and scientists depend upon their senses to gather information.	
Observation Drawing conclusions	Scientific instruments are designed to extend the observer's senses.	
6. Planning Experiments	Experiments are designed to help answer questions a scientist has asked.	
A. A Multitude of problems		Useful Guides and Keys, Lab Investigations (p. 141)
B. Use of references	The first step in answering a question is to find out if the answers are already known.	
C. Preparing for an experiment		Some Experiments with Earthworms (p. 127)

RELATED FILMS

	Min.		
What is Ecology?	11	B&W Color	EBF
The Community	11	B&W Color	EBF
The World of Life	20	Color	McGraw
Life in a Woodlot	17	Color	NFBC
World in a Marsh	22	Color	NFBC
The Pond	20	Color	IFB

OVERVIEW AND RATIONALE

Environment and Life introduces the major theme of the text—how organisms interact with their environment. The reader is taken on an imaginary walk through a natural setting which contains a variety of life forms. This description serves as a sample environment. Students should be able to relate this example to their own more familiar surroundings which also contain a number of living and nonliving factors.

The environment is presented as ever-changing. Organisms are seen as being affected by these changes and responding to them in various ways, as well as being adapted to prevailing conditions. Later chapters are designed to fill in the details of interactions between living and nonliving things, plants and animals, and animals and animals.

The last part of Chapter 1 introduces a secondary theme—how and why biologists do what they do. A biologist is described as a scientist interested in the study of living things. Furthermore, some biologists are concerned primarily with answering questions about organisms and their interaction with environmental factors: the study of ecology. Such questions are answered by making observations, with or without the aid of tools, instruments, and controlled experiments. A good biologist is pictured as keeping accurate records and basing his conclusions on evidence gained by careful observations.

GETTING STARTED

One of your major aims should be to stimulate and maintain student interest in the study of living things. Probably the easiest way to do this is to provide frequent opportunities to observe and work with organisms. Establish this pattern from the start. If possible, have your students work with some living material the first class day. The following suggestion might be used for this purpose:

Put a bit of green aquatic plant, together with a snail or a small fish, in a small jar of water. Discarded baby food jars are about the right size. Prepare such a miniature aquarium for each student, or at least one for every two students. Suggest that the students study the contents of the jars and record what they observe. You probably will have to help them get started. They may observe that the plant is green, the fish is moving, and so forth. Urge them to include as much detail as possible. Are all the leaves the same color? What parts help the fish move? How fast is it moving?

After a time, ask the students to discuss their observations and prepare a class list. Some items may be assumptions rather than observations. Point these out. For example, a student might have listed "bubbles of oxygen come from the leaf." Point out that this is an assumption, since it is not possible to tell what kind of gas is in a bubble without further investigation.

Have the students help identify assumptions on the list. Ask for suggestions of ways to check such assumptions. Ask for questions that grow out of the observations made in this study. Ask for suggestions for ways to answer the questions.

CHAPTER NOTES

Field Observations (page 4) After your students have had an opportunity to read and discuss the imaginary walk presented in Chapter 1, you might want to take them on a walk around the school yard, or into a nearby vacant lot or meadow. Have them record observations as they go. They can list the living and nonliving things they see and ways in which these factors seem to be interacting. Also ask them to list questions that come to mind as they observe. They may want to collect a few specimens for observation and study.

The collection of specimens, however, should not be permitted in violation of existing laws and regulations, which vary a good deal depending on where you are. As the teacher you should, in all cases, be aware of existing restrictions, and advise the students of these restrictions.

Back in the classroom, you can discuss the parallel between the imaginary environment of the text and the student's real environment. There are instructions for preserving specimens in the Laboratory Investigations, page 111. The class may be interested in performing a simple experiment, as an outgrowth of their field study. On page 115, there are instructions for checking the effect of sunlight on plant growth. Plants can be grown by following the directions on page 111.

Individuals or small groups of students may want to test the effect of other physical factors on plant growth. Such ideas should be encouraged, but insist that a plan be worked out on paper and checked by you before an experiment is attempted. Ask the investigators how they plan to keep a record of their observations.

Encourage students to bring small organisms to class, and maintain them for a period of time. This will insure that you have a number of living things to observe and to use as examples in discussion.

When an organism is brought in, have the student find out how to care for it. Also have him label the container with such pertinent information as the name of the organism, where it was found, and what it eats. This will provide a real need to use reference materials and classification aids. To emphasize good conservation practice, insist that each organism be returned to its natural environment after a few days.

In presenting a laboratory or investigation centered program, it is important to "take it slow." Be sure your students know how an investigation fits logically into the sequence of study. Be sure they understand the purpose of such an activity and the directions before beginning. From time to time, let them select the next thing to do. After some data have been collected, students generally will need help organizing and interpreting. Always plan some time for discussion, following a laboratory experience, to take care of this need.

The Study of Biology (page 13) In introducing the idea of biology as a science, you may wish to relate this branch of science to other familiar branches. Students may be acquainted with the names of various physical sciences, such as chemistry, astronomy, geology, and physics. Ask individual students to tell what they understand about the interests of workers in each of these fields. Have them use reference books to find out more about the nature of these branches of science, and have them report their findings to the class.

You may also wish to discuss some of the specialized branches of biology, such as botany, zoology, physiology, microbiology, and ecology. Have students read about these topics in reference books.

Emphasize that in every case the scientist deals with problem solving in his particular field of interest, and although various scientists may use different techniques, they all base their conclusions on careful observations.

LABORATORY SUGGESTIONS

A Pond Culture (page 11, two periods) This laboratory activity provides an opportunity for students to become acquainted with a variety of microscopic plants and animals.

Materials: 6 samples of pond culture, 24 microscopes or one microprojector, 24 slides, and 24 cover glasses.

There are instructions for the use of the microscope on page 112, Lab Investigations.

Use of the microprojector is explained on page 113 of the same section.

If a pond, lake, or slow-moving stream is not available for collecting a pond culture, try a fish pond or a bird bath. Students usually are happy to scout around and locate water samples; however, many such samples probably will be devoid of life forms large enough to study. The same is true of tap water or swimming pool water, that has been filtered and treated chemically. Biological supply houses offer infusoria powder, which contains encysted forms of freshwater pond life. Adding water to the powder usually gives rise to a number of plant and animal types within a few days.

Students usually find the observation of microscopic life very exciting and ask many questions about what they see. They want to know "what it is," "what it is doing," "what will happen if." This provides an opportunity to direct them to reference books, as well as the text. The topic of classification is presented in Chapter 5. Meanwhile, you may want to point out the problem biologists have in classifying organisms, and suggest that the students make up a system to classify the forms they see. They might sketch various types, put them into groups based upon observable characteristics, and even provide descriptive names. Such an activity can serve as an introduction to the problem of classification when it comes up later.

ANALYSIS QUESTIONS (page 11)

1. By moving about, simple, aquatic animals are able to locate food. They also may escape predators and avoid certain harmful environmental factors.
2. Green plants require light for photosynthesis and are not likely to be abundant in mud or ooze where light is dim or absent.
3. Plant and animal populations can be expected to change from day to day. Some environmental factors favor rapid reproduction, other factors cause the death of organisms. As the environment changes, the plant and animal populations will change also.

Some Tests of Observations (page 15, one period) The point to be made from this activity is that our senses are limited and sometimes will fool us. As a consequence, we need special aids and instruments to extend our senses, if we are to make valid observations.

Materials: 24 low power magnifying lenses, 3 electric lamps with unshaded light bulbs.

Students will find it interesting to observe colored magazine pictures, as well as black and white illustrations, under low power magnification.

A variety of after-images can be experienced by staring first at the center of a piece of colored construction paper for 30 seconds and then at a neutral wall or screen.

Other optical illusions can be found in physics texts and various game or puzzle books. Have your students see how many examples they can locate or design to share with the class. Some students may have visited a "fun house" where water seemed to run up hill, and distorted shapes were seen in the mirrors. Have them describe their experiences and attempt to explain how the illusions may have been created.

ANALYSIS QUESTIONS (page 16)

1. Obviously the human eye is not able to detect the shape of very small objects. In fact, if an object has a diameter of much less than 0.1 millimeter the eye may not detect it at all.
2. Every microscope has its "built-in" limits. Simple microscopes may not magnify enough to allow an observer to see skin cells. Viruses are not visible with a compound microscope and although the electron microscope makes possible the study of viral particles, it does not make possible the study of atomic particles.
3. Answers will vary with individual experience.
4. It is not possible to judge relative lengths accurately, and this is the reason scientists use tools such as the millimeter rule to make measurements.
5. Answers will vary.

Some Experiments With Earthworms (page 17, 2 periods) This experiment serves as an example of a kind of investigation done by biologists, in which careful observations and measurements are made. It may also serve to illustrate the idea of a "controlled" experiment and the way data are interpreted.

Materials: 24 earthworms, paper towel, 12 watches, 12 shallow trays, ice, tea, coffee.

This may be the first involved experiment your students have attempted by themselves. There are some important lessons to be learned. For example, students will discover that living things generally are not very cooperative, and as a result, it is often difficult to make accurate observations and measurements. An investigator needs to have great patience to obtain meaningful data.

If possible, have your students collect their own earthworm specimens. This way, they will get more field experience. Have them keep the worms in moist soil, until they are ready to begin the tests. If you have large numbers of worms available, some will probably appear pinker than others. The pinker ones are easier to use. If all the worms are dark, due to soil in the intestines, place them in water for 15 minutes or so. This will tend to clear them. If low power magnifying lenses are available, they will be helpful. The dorsal blood vessel runs along the dorsal midline of the worm, and looks like a pink line that appears and disappears.

You may want students to work in pairs. One can act as the observer while the other keeps track of time and records counts. When the observations have been completed, it will be interesting to record all the data on the blackboard and average the counts. This is a good time to discuss the need for many observations in order to obtain meaningful data and also to discuss the significance of average figures.

It is expected that increasing the temperature will result in an increase in the blood vessel contraction rate. Lowering the temperature should result in a lowered rate of contraction.

If student interest is high, this type of observation may be extended to testing the effect of various chemicals on blood vessel contraction rate. If this is done, it is important to begin with dilute solutions. Then if no effect is noticed, a more concentrated solution can be tried. You may suggest that certain groups test the effects of weak coffee, tea, or a soft drink on the worms. Others may want to use such substances as aspirin, vitamins, or tranquilizers. Dissolve a tablet of the substance to be tested in 100 ml of water to start, then increase the concentration by adding another tablet if no result is obtained.

If earthworms are not available, you may want to substitute snails, tubifex worms, or daphnias. It is necessary to chip off some of the snail's shell to see its heart beating. Low-power microscope magnification will be needed to see the heart in daphnia or the dorsal blood vessel in a tubifex worm. These organisms can be obtained from biological supply houses or from local pet stores.

ANALYSIS QUESTIONS (page 18)

1. It is expected that the worms will show considerable variation in their blood vessel contraction rates. This may be due to natural variation, differences in the species of worms used, differences in age and diet, and variation in room temperature.
2. A decrease in temperature is expected to result in a decrease in contraction rate.
3. An increase in temperature should result in an increase in contraction rate. Generally, as temperature increases, chemical reactions proceed more rapidly. Since blood vessel contractions are due to a series of chemical reactions, we can expect a similar response in them.
4. Every measurement may differ slightly from every other one. As an investigator cannot select any one of the group as the "best" measurement, it becomes useful to calculate the average.
5. Answers will vary; but they should be affirmative.

WORD MEANINGS (page 19)

1. adapted—adjusted to the conditions of life
2. aquatic—organisms that live in water
3. biology—the study of living things
4. cells—the basic units of structure and function in plants and animals
5. environment—everything in your surroundings
6. fungi—plants that cannot make food
7. control—comparing results obtained from many organisms
8. protoplasm—the living substance.

SELF TEST (pages 19-20)

1. False. Ecology is the study of the interrelationships of organisms with their environments.
2. True
3. True
4. True

5. False. An afterimage is a different color than the actual image.
6. False. It is not always possible to judge the relative size of objects by looking at them.
7. True
8. False. Biology is the study of all living things.
9. True
10. True
11. False. Cells are found in both plants and animals
12. True.

DISCUSSION QUESTIONS (page 20)

1. Green plants affect us by providing food, materials for shelter and clothing, and chemicals of various kinds. They also release oxygen into the air and add to the beauty of our surroundings. Some green plants are weeds. Others affect the flavor of our drinking water. Some nongreen plants are used as food, and some provide us with drugs. Some cause diseases, and still others cause decay. Animals provide us with food and materials for clothing and some serve as pets. They add beauty to our world, although certain species may endanger our lives. Among the latter are types that cause or carry diseases.

   One of the physical factors that affects us is sunlight which provides us with heat and is the source of energy stored in food and fuels. We also are affected by the gases and pressure of of the air, the presence or absence of water, and the types of soil that occur nearby. We are affected in numerous ways by the shape of the land and the presence of large bodies of water, such as lakes and oceans.
2. During a twenty-four hour period, the intensity of light changes, and temperature and moisture conditions vary. Our environment changes constantly, as we move about. During the year, seasonal changes bring about changes in our surroundings, which are reflected in the number and kinds of living things we encounter. In the past 10,000 years, our environment may have undergone changes in elevation, temperature, moisture, and number, as well as in kinds of living things.
3. Nongreen plants are like animals in that they cannot manufacture food. However, plants are less likely to move about. Cellular differences and similarities are discussed in Chapter 3.
4. Water flowing from a spring is ground water that fell first as rain and is moving downhill. Because of the rock structure, it seeps out of the ground at the location of the spring.
5. Any change in the surroundings can be expected to produce some reactions on the part of organisms.
6. Many of the organisms that freeze solid in a pond will die, but some forms may survive. This can be tested by freezing some pond water, known to contain a variety of tiny plants and animals, thawing it, and seeing what forms continue to carry on observable life processes. An unfrozen sample of water should be kept as a control to see if organisms are affected by factors other than freezing.
7. Scientists are motivated to study nature simply to add to their fund of knowledge, which is shared freely. From this knowledge, others may find ideas of practical importance. It often is impossible to predict what will be discovered by scientific activity or what application can be made of the discovery.
8. a) The organized study of living things began as early as three centuries before the birth of Christ. Even before, men had learned much about the nature of plants and animals while hunting for food.

   b) Many questions about living things remain unanswered. It has been said that knowledge expands like a balloon. The air around it represents the unknown. The larger the balloon becomes, the greater the surface that contacts the unknown. Or putting it another way, the more we know, the greater the number of questions we can ask.

9. Biologists, as a group, are more likely to be aware of sense limitations and the difficulty of making accurate observations. They also are more likely to employ measurement and controlled experiments in their observation techniques.
10. Of course, it would depend largely on how much iodine was used. However, it is common knowledge that iodine is poisonous, so it could be expected to have some effect on pond water organisms. This could be tested by adding varying amounts of iodine to different samples of culture. An untreated sample should be kept for comparison; that is, as a control.
11. The best way to find out whether one object is longer than another is to measure the length of each with a rule. Similarly, a balance may be used to compare weights.
12. Every microscope has limitations. The ordinary laboratory microscope will allow the observer to study objects the size of cells, but not viruses. Viruses can be studied with an electron microscope, but atoms cannot.
13. Optical illusions demonstrate that it is possible to be mistaken about something that is seen. We sometimes can tell when we are being misled, by making measurements with scientific instruments.
14. Microscopes and telescopes extend the sense of sight. Radio extends hearing, and television extends both sight and hearing. Geiger counters allow us to detect certain forms of radiation which we can neither see nor hear.
15. To set up a good experiment, the investigator must first decide what it is he wants to find out. Then he must decide how best to accomplish this, within the limitations of his knowledge, ability, reference materials, and equipment. He must take care to design an experiment that is controlled, and from which accurate observations and measurements can be obtained. Finally, he must carefully analyze the data collected before reaching a conclusion about the meaning of the results.
16. Actually, it is not easy to tell whether some things are living or nonliving—a fact that is discussed in Chapter 5. There are, of course, "rules of thumb" that are useful in distinguishing many life forms from nonliving material. For example, living things generally move, respire, make use of food, give off wastes, reproduce themselves, grow, and respond to stimuli. Of these, probably the quality most characteristic of living things is the ability to reproduce. In addition, as is discussed in Chapter 3, living things are composed of microscopic cells, which contain a characteristic substance called protoplasm.

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CHAPTER 2 The Living Substance

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Matter is anything that occupies space and has weight. Our world is made up of matter in the form of solids, liquids, and gases.	Materials of the classroom, see Getting Started, Chapter 2, Teachers Guide (p. 11)
2. Elements and Their Atoms	All the material of the environment consists of elements and combinations of elements. Elements are composed of tiny particles called atoms.	
A. Matter		
B. Elements		Things To Do, #1 (p. 39)
C. Atoms	Atoms are made up of still smaller particles.	Things To Do, #7 (p. 39)
Isotopes	When an element has more than one kind of atom, these different kinds are called isotopes.	Things To Do, #8 (p. 39)
Radioactive atoms	Some atoms are unstable and give off particles and energy.	Radioactive Substances (p. 117) Things To Do, #9 (p. 39)
D. Molecules and compounds		
Compounds	Atoms of different elements sometimes bond together to form compounds.	Things To Do, #2 (p. 39)
Molecules	Whenever atoms are bonded together the resulting particles are called molecules.	Things To Do, #3 (p. 39)
3. The Nature of Protoplasm		
A. The elements of protoplasm	The compounds in living material are responsible for the things it can do.	
B. The appearance of protoplasm	Protoplasm is a complex, everchanging substance.	Observation of **Elodea** Cells (p. 26)
4. Compounds of Protoplasm		
A. Water	Protoplasm consists primarily of water and materials dissolved in it.	Water in Protoplasm (p. 34)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
B. Carbohydrates	All life processes require energy.	Testing for Compounds of Protoplasm (p. 32)
C. Fats	Carbohydrates and fats serve as energy sources for living things.	
D. Proteins	Proteins are responsible for carrying out a variety of life processes.	Things To Do #6 (p. 39) Carbon Compounds (p. 116)
E. Enzymes	Enzymes are special proteins that control the rate of chemical changes in protoplasm.	An Enzyme of Protoplasm (p. 35)
5. Other Compounds in Protoplasm		
A. Hormones	Hormones are chemicals carried in the blood that influence the activity of certain cells.	
B. Nucleic acids	Nucleic acids are self-duplicating molecules that determine what goes on in a cell.	
C. Salts		
6. Energy for Work		
A. The process of oxidation	Energy is stored in the bonds between atoms in food molecules. When oxygen combines with these molecules, bonds are broken and energy is released.	Things To Do #5 (p. 39)
B. Some properties of protoplasm	Energy is used for movement, growth, repair, and removal of wastes.	Things To Do #6 (p. 39)

RELATED FILMS

	Min.		
Elements, Compounds, and Mixtures	34	Color	MLA
Carbon and Its Compounds	11	B&W Color	COR
Conquest of the Atom	22	Color	IFB
A Cell's Chemical Organization	28	Color	McGraw
Cell Respiration	30	Color	McGraw

OVERVIEW AND RATIONALE

Chapter 2 is concerned with the chemical aspects of the environment and begins to fill in some details of the broad ideas presented in Chapter 1. The materials of the environment are composed of atoms and molecules, as is the living material. A study of protoplasm shows it to be a transparent, jellylike substance containing tiny granules and larger organized structures. It is capable of movement and certain other activities characteristic of life. Analysis of the living substance reveals it to be composed largely of water. Certain complex substances are dissolved in the water, including carbohydrates, fats, proteins, and salts.

The things protoplasm can do are determined by the kinds of chemicals that are present. For example, special proteins called enzymes make it possible for certain vital chemical changes to take place. Other chemicals, such as hormones and nucleic acids, play important roles in the control of cell behavior.

Energy to promote cell activities is obtained from food materials, where it is stored in the bonds between the atoms of molecules. The energy is released by oxidation, which involves breaking chemical bonds and transferring energy from food molecules to special energy-carrying molecules within the cell. Thus, protoplasm is a chemical system depending on its environment for the essentials of life.

GETTING STARTED

Some students may find the material of this chapter somewhat difficult to understand. It deals with unfamiliar aspects of the environment, and some of the ideas are rather abstract. One cannot, for example, experience atomic particles directly. Students will need help relating this information to their own surroundings.

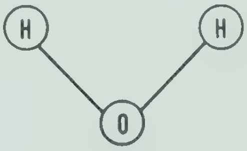
You might begin by asking the class to group the materials of the classroom as solids, liquids, and gases. This is an experience in classification, and can be referred to later on when dealing with plant and animal classification in Chapter 5. Individuals can prepare lists, and these lists can be summarized on the blackboard in a class list.

Such an activity can be expanded by asking students to list common elements and compounds. If there is a question as to whether a substance is a compound or an element, reference books can be consulted. Some students may be interested in displaying collections of common elements and compounds. (See *Things To Do*, items 1 and 2, page 39.)

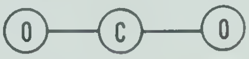
CHAPTER NOTES

The Elements and Their Atoms (page 23) To gain some understanding of the relationship between atoms and molecules, students can prepare models of common molecules. (See *Things To Do*, item 3, page 39.) Many kinds of small objects can be used as model atoms: marbles, beads, clay, styrofoam, and others. Different colors can represent atoms of different elements, and the models can be labeled with chemical symbols. Bonds between atoms can be represented by toothpicks, wire, or pipe cleaners.

A water molecule (H_2O) model can be constructed with two hydrogen atoms bonded to an oxygen atom.

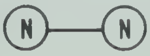


A carbon dioxide (CO_2) model would be made with one carbon atom and two atoms of oxygen.

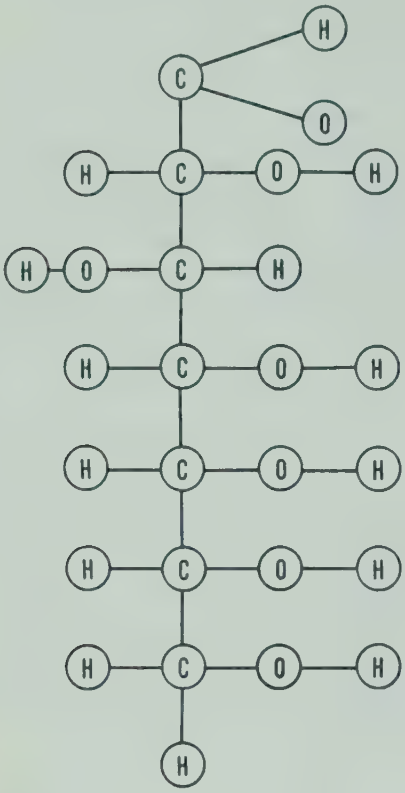


An oxygen gas molecule model (O_2) would be made with two oxygen atoms bonded together.

A nitrogen gas molecule (N_2) would be represented by two nitrogen atoms bonded together.



A simple sugar molecule, such as glucose ($C_6H_{12}O_6$) could be constructed like this:



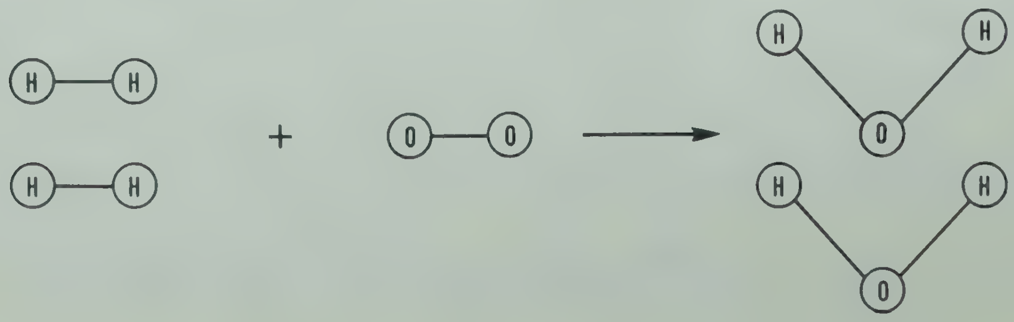
Most high school and college chemistry text books will provide illustrations for other examples.

You may want to illustrate a chemical reaction using such models. For example, the reaction that takes place when hydrogen gas and oxygen gas combine to form water can be illustrated with the models shown at the bottom of page 12. Thus, two hydrogen molecules plus one oxygen molecule produce two water molecules.

The Nature of Protoplasm (page 25) If you decide to discuss the elements of protoplasm in more detail than is presented in the text, you may wish to list some of the other elements found in living things. In addition to oxygen, carbon, hydrogen, and nitrogen, the list includes phosphorus, sodium, potassium, sulfur, chlorine, magnesium, calcium, and iron. Several other elements including iodine, copper, silicon, and manganese usually occur in smaller quantities. You also might point out that certain elements, such as copper and manganese, are known to be necessary for the action of various enzymes.

Compounds of Protoplasm (page 28) Generally, plant and animal tissues are composed of 75-85 percent water, 15-20 percent protein, 2-4 percent fat, and about one percent carbohydrate. In addition, about one percent of the weight of a tissue sample is due to miscellaneous substances, including salts. Be sure to emphasize that although water is by far the most abundant compound in living material, it is the protein that is primarily responsible for the characteristic qualities of protoplasm. Emphasize also that carbohydrates provide the basic energy supply for protoplasm, while fats are most likely to be associated with membranes within the cells.

Almost all of the many chemical reactions that take place in protoplasm are influenced by enzyme molecules. Although enzymes generally seem to consist of protein, some enzymes have an additional, non-protein, part. In a number of instances, this non-protein part is formed from a vitamin molecule, so that the protein and the vitamin together make up the enzyme molecule. Thus, without the vitamin, the enzyme cannot be formed, and a vital chemical reaction may not take place.



You also might want to mention that the nucleic acids determine what goes on in a living cell by controlling the manufacture of specific enzymes. The enzymes, in turn, influence specific chemical reactions, which are characteristic of a particular kind of protoplasm.

Energy for Work (page 36) Energy can be defined as the capacity to do work, and energy is required by the living material, as it carries on its many activities, including the movement of molecules from place to place. Energy takes many forms, including light energy, heat energy, and chemical energy. It is important to point out that energy can be changed from one form to another. Thus, light energy from the sun may be converted to heat energy, as it is absorbed by our skin, or it may be converted to chemical energy in the leaf of a green plant. In any event, protoplasm is dependent upon chemical energy—energy stored in the bonds between atoms of carbohydrate molecules. This stored energy is released by the process called oxidation, and the energy is passed to other molecules, such as *ADP* when it becomes *ATP*. Then, the energy carried by *ATP* molecules may be used to do work in a cell. In a way, energy is passed from one molecule to another like money is passed from one person to another.

LABORATORY SUGGESTIONS

***Elodea* Cells** (page 26, one class period) provides an opportunity for students to examine the protoplasm in some living cells.

Materials: Elodea, 24 microscopes, 24 slides and 24 cover glasses.

Elodea (often known as *Anacharis*) is a common freshwater plant, and can be obtained in aquarium supply houses and pet stores, as well as from biological supply houses. If the plant is left in sunlight or strong artificial light for an hour or so before use, students are more likely to see movement within the cells. Under such conditions, the cell contents move in a circular path. This is termed "cytoplasmic streaming." You might ask students to see if the streaming is always in the same direction. They should note that an *Elodea* leaflet is built of cells, much as a brick wall is built of bricks. They should also see the cell walls that outline individual cells and the tiny green chloroplasts. These parts can be seen with low power; however, unless high power is used, it is unlikely that the students will see granules or a nucleus. The nucleus is about as transparent as the cytoplasm in which it is located. Special stains are often used to make it visible.

ANALYSIS QUESTIONS (page 27)

1. The protoplasm in *Elodea* cells is transparent, granular, and jellylike. It contains tiny green objects that move about within the cell.
2. The green color of the leaflet is due to the tiny green objects (chloroplasts) in the protoplasm of the cells.
3. The cells vary in their shape. They are commonly rectangular in outline, and two or three times longer than they are wide. They also vary in size. The cells are larger near the midrib and the base of the leaflet.

Testing for the Compounds of Protoplasm (page 32, three class periods)

This exercise is multipurpose. It provides an opportunity for the student to discover for himself which of several substances can be used to test for certain compounds, and then to apply this test to unknown materials. It introduces the ideas of qualitative and quantitative observations, and it introduces a number of common laboratory techniques, such as heating substances in test tubes, handling reagents, using color change as an indication of chemical activity, and the use of the balance.

Part I demonstrates that sugars, starches, proteins, and fats are present in many kinds of protoplasm and is an example of a qualitative experiment. *Part II* illustrates the fact that water makes up a large percentage of the weight of living material. This is a quantitative experiment. *Part III* demonstrates that one particular enzyme, catalase, is common in protoplasm of various types. *Part IV* provides an opportunity for the student to test the effect of an environmental factor on the action of catalase.

Tests for Sugars, Starches, Proteins, and fats (page 33, one period)

Materials: 24 test tubes, 24 test tube holders, Biuret reagent, Fehling's solutions A and B, 12 Bunsen burners, 24 watch glasses, iodine solution, unglazed paper, starch, glucose (also called dextrose), gelatin, salad oil, a variety of plant and animal materials to test (potatoes, carrots, onions, lettuce, fish, earthworms, insects, ground meat, etc.).

This exercise is planned so that the student must discover for himself the test that can be used to determine the presence of a given substance. He should determine that Fehling's solution turns a coppery color in the presence of heat and sugar, iodine solution causes starch to become blue-black, and the oil leaves a translucent spot that does not evaporate on unglazed paper.

Biuret reagent can be prepared by adding 25 ml of a 3 percent solution of copper sulfate to a liter of 10 percent potassium hydroxide.

Other tests for simple sugars might be substituted for Fehling's solution. Benedict's solution also produces a coppery color when heated in the presence of a simple sugar. Sugar test papers are sold in drug stores and by chemical supply houses.

Iodine solution is prepared by dissolving 10 grams of potassium iodide in 100 ml of distilled water. To this is added 5 grams of iodine.

All of these solutions should be handled with care as they are poisons and should not be allowed to come in contact with the skin. Students should also be cautioned to point test tubes away from themselves and others while heating solutions. The contents of tubes should be heated slowly and gently to avoid rapid boiling over.

ANALYSIS QUESTIONS (page 34)

1. All samples of protoplasm, no doubt, contain proteins, fats, and carbohydrates, since these substances are necessary for life. However, some of the substances will be present in concentrations too low to be detected by the tests used in this exercise. On the other hand because of the specialized function of certain tissues, a particular substance will sometimes be quite concentrated within the cells. For example, the cells of a potato store carbohydrates in the form of starch.
2. The plant samples are more likely to indicate the presence of starch and sugar, while the animal tissues are more likely to exhibit the presence of proteins.

Water in Protoplasm (page 34, one period)

Materials: plant and animal samples (as in the previous activity), two balances, two drying ovens.

The success of this investigation depends in a large degree on the balance used. If very small samples are selected, a balance sensitive to 0.1 grams or less probably will be needed. If available balances are less sensitive, larger samples should be used. Care must be taken not to burn the samples when drying them. Set the oven at the lowest heat possible and leave the samples until they are completely dry. If the samples smoke and turn black, too much heat is being applied. Weigh the samples as soon as possible after drying, because some types may tend to absorb moisture from the air.

ANALYSIS QUESTIONS (page 35)

1. Answers will vary.
2. Since the weight of protoplasm is due primarily to water, this compound must

be considered important to living material.

3. This is a quantitative investigation, because it is concerned with determining *how much* water is present in protoplasm.

An Enzyme of Protoplasm (page 35, one period)

Materials: test tubes, plant and animal samples, hydrogen peroxide (3% in water).

The presence of catalase can be demonstrated in a wide variety of plant and animal substances. However, animal tissue generally shows more activity than does plant tissue. The hydrogen peroxide solution can be obtained from a drug store or a chemical supply house. An inch of solution in a test tube can be used for several tests, so long as it does not become badly contaminated. For example, a piece of potato might be lowered into the test solution on the end of a piece of wire. As soon as the observer noticed bubbles, the potato would be removed and another sample could be tested. In time, of course, the hydrogen peroxide will be exhausted and must be replaced.

ANALYSIS QUESTIONS (page 35)

1. Answers will vary.
2. Generally, animal tissue shows more activity than plant tissue.
3. Even though all the samples tested showed evidence of catalase, one should not conclude that *all* living things contain this enzyme. The evidence is too limited.
4. These tests were qualitative because they demonstrated a quality of protoplasm (the presence of catalase), rather than how much catalase was present.

An Investigation You Can Plan (page 36)

Materials: test tubes, plant and animal samples, hydrogen peroxide (3% solution in water), thermometer, beaker, hot water, ice.

A sample can be heated by placing it in a test tube and then putting the tube in a beaker of hot water. If the water is too hot, an ice cube can be added to lower the temperature. Similarly, a sample can be cooled by placing it in a tube in a beaker of ice water. Warm water can be added if the temperature drops too low.

ANALYSIS QUESTIONS (page 36)

1. An increase in temperature is expected to produce an increase in activity, while a decrease in temperature should produce a decrease in activity for both plant and animal tissues.
2. This was a qualitative observation, but might have been made quantitative by determining how much gas was produced by equal sized samples at different temperatures.

WORD MEANINGS (page 37)

A

1. atom—the smallest part of an element having all the properties of that element
2. matter—includes all substances that exist in our environment
3. molecule—the smallest unit of a compound formed when atoms bond together
4. oxidation—a process in which oxygen combines with a food material and energy is released
5. protein—compound that contains carbon, hydrogen, oxygen, and nitrogen

B

1. amino acid—a smaller molecule that results when a protein molecule is digested
2. *ATP*—a molecule that is an energy carrier
3. energy—the capacity to do work
4. enzyme—the general name given to a substance that speeds up certain chemical reactions
5. *ADP*—a molecule that stores energy re-

leased by oxidation
6. hormone—a "chemical messenger"
7. nucleic acid—may contain *DNA* or *RNA*

SELF TEST (pages 37-38)

1. False. Protoplasm is made up of materials that are also found in nonliving materials of the world.
2. True
3. True
4. True
5. False. Enzymes are special types of protein.
6. False. *DNA* and *RNA* are nucleic acids.
7. True
8. True
9. True
10. False. A formula indicates the number as well as the kind of atoms in a molecule.
11. False. A molecule of water consists of only two kinds of atoms.
12. False. The most common elements in protoplasm are carbon, hydrogen, oxygen, and nitrogen.
13. True
14. False. Biuret reagent turns purple in the presence of protein.
15. False. Hormones are produced in a variety of special glands, and are *transported* by the blood.
16. True
17. True
18. True

DISCUSSION QUESTIONS (page 38)

1. Solids have definite shapes and volumes. Liquids have definite volumes, but take the shapes of their containers and can be poured. Gases take the shapes, and volumes of their containers. Solids, liquids, and gases are alike in that they have weight, take up space, and are composed of particles.
2. Radioactive substances are used as a source of heat energy, which can be used to make electricity and operate engines. They also are used as "tracers" by scientists. This means their "paths" in chemical reactions or in the bodies of living things can be followed by the radiation they give off. They are used to treat certain diseases and to sterilize objects.
3. The evidence that atoms exist is indirect. Assuming that they do exist makes it possible to explain a great many observations that have been made on the structure of matter. For example, the differences between solids, liquids, and gases can be interpreted with this idea. If each is made of particles, then the particles must be closely packed in the solid and have great attraction for one another. In the liquid, the particles must be farther apart with less attraction, and in a gas the particles must be very far apart and have little attraction for each other. Thus, the idea of atoms or the atomic theory is a useful generalization that helps scientists in their attempts to explain the nature of things.
4. As living cells, all of these must contain similar vital chemicals—carbohydrates, proteins, fats, water, salts, enzymes, and nucleic acids. They also must be able to carry on life processes, such as the oxidation of food materials. They differ in size, shape, and ability to carry on special functions. For example, the cell of a hen's egg stores a great deal of food in a form that can be used by a developing chick, a potato cell may store another form of food for the potato plant, while the *Elodea* cell can make its own food in the presence of sunlight, water, and carbon dioxide.
5. Water makes up the bulk of most living things. It is in water that the chemicals of protoplasm are dissolved, and only in such a solution can the vital chemical reactions of life take place.
6. $C_6H_{12}O_6$ is the formula for a simple sugar like glucose. It represents one molecule of sugar that consists of

six atoms of carbon, twelve atoms of hydrogen, and six atoms of oxygen.

7. A potato is a specialized stem (Irish potato) or root (sweet potato) of a potato plant. Carbohydrates are a special group of chemical compounds. Although the potato may contain a great deal of carbohydrate, it also contains other chemicals as well, including some protein, fats, and minerals. Similarly, beef contains a good deal of protein, but may also contain other chemicals characteristic of living things.
8. Fats and carbohydrates are similar in that they represent groups of chemical compounds consisting of carbon, hydrogen, and oxygen atoms. Both kinds of chemicals hold energy available to living things in the bonds between the atoms. They differ, however, in the way the atoms are arranged and in the proportion of atoms present in the molecules. Carbohydrates, generally have twice as many hydrogen as oxygen atoms, while fats have many more hydrogen than oxygen atoms.
9. Proteins are important in protoplasm as molecules of structure. That is, vital parts of nuclei and cytoplasms are composed largely of proteins. Proteins also make up parts of enzymes, which in turn control the vital chemical reactions in living things.
10. Amino acids joined together in chains make up protein molecules. Thus, amino acids are the building blocks of proteins.
11. Qualitative observations concern qualities of objects, such as color, size, shape, and the presence or absence of certain substances. Quantitative observations involve measuring quantities, and reveal how much of a given substance is present.
12. The activities of protoplasm are called life processes. These include movement, response to stimuli, use of food, digestion, excretion, respiration, growth and repair, and reproduction. (Each of these topics is discussed in Chapter 3)
13. Many of the activities carried on in living things can be observed in nonliving material. An automobile can be used as an illustration. It can move, requires "food" (fuel), obtains energy by oxidation, gives off wastes, and responds to changes in the environment, such as temperature changes.
14. The ability to reproduce and build complex compounds from simpler ones and the presence of cell structure probably are the most useful characteristics for distinguishing living from nonliving things.

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CHAPTER 3 Cells in Action

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction		Observing plant and animal cells, see Getting Started, Chapter 2. Teacher's Guide (p. 20) Use of the Microscope (p. 112) Temporary Microscope Mounts (p. 114) Use of the Simple Projector (p. 113)
2. Cells: The Units of Structure and Function		
A. Units of structure	The bodies of plants and animals are built of cells.	
B. Units of function	The activities of plants and animals are performed by cells.	
C. General characteristics of cells	Although cells generally vary in size, shape, and function, they have much in common.	Things To Do, #4 (p. 57) Things To Do, #6 (p. 57)
3. Animal Cells		Things To Do, #1 (p. 56)
A. Cell parts	A typical animal cell possesses cytoplasm, a nucleus, and a cell membrane.	Things To Do, #2 (p. 57) Living Membranes (p. 118)
B. Motion and locomotion	Cells move by a variety of means—fingerlike processes, cilia, or flagella.	Things To Do, #3 (p. 57)
C. Response to stimuli	Protoplasm is sensitive to changes in its surroundings and can make responses.	Behavior in Paramecium (p. 121)
D. Food and digestion	Animal cells must be provided with food for energy, growth, and repair.	
E. Use of oxygen	Most living things require oxygen in order to obtain energy stored in food molecules.	
F. Waste removal	Waste chemicals from life processes must be removed from cells.	
G. Growth and repair	A living cell is in a constant state of change.	
H. Cell division	When a cell grows to full size it may divide to form two new cells.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
4. Paramecium—A Single-celled Animal	Paramecium is an example of a single-celled organism and can be used to illustrate cell structure and functions.	An Observation of Paramecium (p. 48) Cultures in the Laboratory (p. 109)
A. Shape and structure		
B. Food and digestion		
C. Oxygen supplies		
D. Excretion of wastes		
E. Growth and cell division		Behavior in Paramecium (p. 121) (fission)
5. Plant Cells		
A. Cell parts	In addition to a cell membrane, cytoplasm, and a nucleus, plant cells have a cell wall and some possess chlorophyll.	A Single-celled Plant (p. 51) An Activity of Cell Membranes (p. 53) (Testing Cells of a Beet Root)
B. Food manufacture by plants	Chlorophyll bearing cells can make food from nonliving material—water and carbon dioxide. Sunlight provides the energy for photosynthesis.	Stored Starch in Green Leaves (p. 122) Things To Do, #5,7,8 (p. 57) Discharge of Oxygen by an **Elodea** plant (p. 123) Plant pigments (p. 124)
6. Nongreen Plants		
A. Some plants are dependent	Some nongreen plants cannot make food and must obtain it from their environment.	An Activity of Cell Membranes (p. 53) (a test using yeast cells)
B. Some special food-making processes	Some nongreen plants can make food using chemical energy rather than sunlight.	

RELATED FILMS

	Min.		
The Cell: Structural Units of Life	10	Color	COR
The Life and Death of a Cell	26	Color	UC
Cells and Their Functions	14	B&W	CF
What is a Cell?	28	Color	McGraw
Colour of Life	24	Color	NFBC
Photosynthesis	21	Color	EBF
Paramecium	11	B&W	UWF

OVERVIEW AND RATIONALE

Chapter 1 concerned the broad aspects of the environment, while Chapter 2 dealt with the chemical features of the environment. This chapter focuses attention on the cellular structure of living things and some of the ways in which cells interact with chemical factors of the environment.

The structure and functions of plant and animal cell parts, such as cytoplasm, nucleus, cell membrane, nuclear membranes, granules, and vacuoles are described. This is followed by a discussion of cell processes—motion, locomotion, response to stimuli, food getting, digestion, waste removal, growth, and repair. The topic of reproduction by cell division is introduced also.

The single-celled organism Paramecium is presented as an example of an organism which carries on such life processes. Certain plant cells are distinguished from animal cells by the presence of cell walls and chlorophyll. The process of photosynthesis by which green plants can manufacture food from nonliving material of the environment is described.

The chapter ends with a discussion of nongreen plants—plants that make food by other methods or cannot make food and must obtain it from an outside source.

GETTING STARTED

If microscopes are available, you may want to have students prepare slides from a variety of tissues and observe cells. Or you can demonstrate such a variety of cells using a microprojector. The purpose of this is to have students discover for themselves that cells are present in living materials generally and that cells have much in common regardless of their source.

Provide a variety of plant and animal tissue to study. Such plant materials as leaves, onions, carrots, tomatoes, celery, and others will serve well. Students will want to suggest still other samples to observe. Thin sections of tissue can be prepared by following the instructions on page 114. If a blender is available, a sample of plant material and a little water can soon be converted into a "cell soup." A drop of this on a slide provides a variety of thin sections.

Students can remove cells from the inside of their cheeks by rubbing the tissue gently with a toothpick. Then the toothpick should be stirred in a drop of water or a drop of iodine solution on a slide. Cheek cells are fairly large and have visible nuclei. Small pieces of meat of various kinds will provide animal tissue to observe. A very tiny piece of meat can be placed in a drop of water and can be teased apart with a pair of dissecting needles.

A staining technique is described on page 115. This will be helpful to demonstrate how stains make certain cell parts more readily visible.

After students have had an opportunity to observe a variety of cells, you might have them list ways in which cells generally are similar and how they are different. You can ask them to predict what other materials contain cells and what these cells might look like. Their predictions can be verified by examining slides of the materials in question.

CHAPTER NOTES

Cells: The Units of Structure and Function (page 41) In presenting the idea of cells as units of structure, it might be well to point out that there are various levels of organization in the structure of living things. Chapter 2 deals with the structure of atoms and molecules. That is, atoms are composed of subatomic particles. Atoms bonded together form molecules. Molecules form the structure of protoplasm and cells. Cells, in turn, are the units of structure in an organism.

This idea will be developed further in Chapter 4, where tissues are discussed as being made up of cells; organs are built of tissues; systems are groups of organs; and complex organisms are composed of organ systems. In other chapters, populations are described as groups of organisms, and communities are described as groups of populations.

Animal Cells (page 41) Throughout this section, reference is made to movement of molecules—molecules move about in protoplasm, food molecules pass through cell membranes, an ameba takes in oxygen molecules, and carbon dioxide wastes are discharged into the surroundings. It is possible to demonstrate an effect of molecular movement and show that this effect is related to temperature by doing the following:

Fill three beakers with water. Heat one to boiling, leave the second at room temperature, and cool the third with ice. Gently place a drop of ink or stain on the water surface in each beaker. Have the students watch the colored material in the water.

Before adding the stain, you may want to have students predict what they will observe. They probably will reason that the water molecules are moving and the stain molecules are moving too. As a result, the stain will mix with the water. Also, because heat is a form of energy, the warmer the molecules get, the faster they will move. Thus, the stain in the hot water will mix most rapidly.

The stain will be seen apparently mixing itself into the water of each beaker. Point out that the net movement of stain molecules is from regions of higher concentration to regions of lower concentration. This is an example of diffusion, and diffusion is the process whereby molecules move about in protoplasm, and pass in and out of cells through cell membranes.

Plant Cells (page 49) After discussing the ways in which plant and animal cells differ, you might have students relate this information to differences they observe in familiar organisms. For example, chlorophyll is responsible for the dominant color of grass and leaves. The stiff cell walls of plant cells make for hard, tough, plant tissue, while animal tissues lack cell walls and are often more flexible.

Emphasize the importance of photosynthesis as the basic food-making process, upon which nearly all living things depend for their food supplies. This idea will be developed in later chapters.

Nongreen Plants (page 52) It may be important to point out that nongreen plants, as it is used in this section, means non-chlorophyll bearing plants. Some plants contain chlorophyll, but do not appear green, and might be called nongreen incorrectly. Mushrooms or toadstools, bread molds, yeasts, various fungi, and most bacteria are nongreen. On the other hand, various seaweeds are brown or red, but also contain chlorophyll. The same may be true of certain garden plants that contain an abundance of red pigment in their leaves and stems, in addition to chlorophyll.

LABORATORY SUGGESTIONS

An Observation of Paramecium (page 48, one class period)

This activity provides an opportunity to study a fairly large single-celled organism that is visibly active and carrying on a number of observable life processes.

Materials: 24 microscopes, 24 slides, 24 cover glasses, paramecium culture, iodine solution.

Paramecium is quite common in freshwater ponds, and if your students have established cultures of microorganisms, they may have noticed these forms already. If a culture is not available, one can be obtained from a biological supply house.

Have students watch active paramecia for a time and list any observations that indicate life processes. They will see motion and locomotion and may see evidence of food getting, response to stimuli, or cell division.

If the organisms are moving too fast to observe, they may be slowed down by adding a bit of cotton or lens paper that has been pulled apart so the organisms become trapped among the fibers. After a time, enough water will have evaporated from the slide so the cover glass presses on the organisms and slows them down. Sometimes paramecium can be slowed down by adding a little syrupy methyl cellulose to the drop of culture material. Try a 10% solution of methyl cellulose in water (one gram of methyl cellulose dissolved in nine ml of water).

ANALYSIS QUESTIONS (page 49)

1. Paramecium appears to move very fast because distance as well as size is magnified by the microscope. (Students may be interested in measuring the rate of movement of microscopic organisms. To do this, it is necessary to know the distance across the microscope's field of view. This can be determined by viewing the scale of a transparent ruler. Then, the time it takes for an organism to move from one side of the field to the other can be measured and the rate of movement calculated.)
2. Paramecium may be described as cigar shaped with an oval or circular cross section. It is difficult to judge the thickness, unless it is viewed in a drop of water without a cover glass, and is observed swimming directly toward the lens.
3. Because paramecium has a lower water concentration on the inside of its cell body than exists around it, and the cell membrane is permeable to water, water enters the cell continually by the process called osmosis. Water also is forced into the cell by cilia that surround the mouth opening. Excess water must be removed continually, or the cell will burst. This is the function of the contractile vacuoles.
4. Oxygen is necessary for paramecium and living things generally, for carrying on oxidation and releasing the energy of foods.
5. As it moves about, paramecium bumps into objects. When this happens, the organism will often reverse its direction and thus avoid the object. Also, the release of trichocysts in the presence of iodine may be considered as a response to an external factor.

A Single-celled Plant (page 51, one period)

This investigation provides a chance to study a simple plant and see some plant cell parts.

Materials: 24 microscopes, 24 slides, 24 cover glasses, green algal culture.

Students may be able to find colonies of the simple alga, *Protococcus,* which forms a green covering on damp objects in greenhouses, on fences, and on the bark of trees. Species of *Euglena* or *Chlamydomonas,* both of which are capable of locomotion, occur in pond water. If such forms cannot be located, cultures may be purchased from biological supply houses.

Algae are fairly easy to study. Even if they move, they move relatively slowly. Students should be able to see the outer covering or cell wall and the greenish contents of the cell due to the presence of chlorophyll. They also may see the chloroplasts that hold the chlorophyll. If *Euglena* or *Chlamydomonas* is used, a rust colored "eye spot" often can be seen near the forward end of the cell, and under high power in dim light a threadlike flagellum may be observed. The nucleus of *Protococcus* can be seen more easily if it is stained with iodine solution.

ANALYSIS QUESTIONS (page 52)

1. Land-dwelling algal cells obtain water from their surroundings by diffusion into the cells or by absorbing moisture from the air. They are largely restricted to damp areas such as greenhouses, swamp lands, or on the moist bark of trees.
2. Green algae depend on light for photosynthesis, and cannot make food in the absence of light. Some of the motile forms like *Euglena* have been reported to take in food from the outside, when deprived of light.
3. Oxygen gas is discharged when green algal cells carry on photosynthesis.

An Activity of Cell Membranes (page 53, one to three class periods)

This exercise has three parts. The first, *Testing Cells of a Beet Root,* is a simple demonstration to show that an environmental factor (heat) can alter cell membranes so that the cell contents leak out. Part two, *A Test Using Yeast Cells,* demonstrates much the same thing, but requires more careful laboratory technique and is for the more capable student. It also sets the stage for part three, which is planned for the student who wants to go one step further, using the congo red technique to investigate the effect of another environmental factor on cell membranes. Depending on class ability, you may want to adjust your presentation.

Testing Cells of a Beet Root (page 53, one period)

Materials: beet, knife, beaker, water, heat source.

With a capable class, you may decide to use this as a class demonstration to be performed by two or three students for the benefit of the others. The heated water will become stained, as the beet cell membranes are altered. The unheated water will remain nearly clear, as the cell membranes continue to function.

ANALYSIS QUESTIONS (page 53)

1. Water in the heated beaker becomes red, while water in the other beaker remains colorless.
2. Heat altered the cell membranes so that they no longer functioned to hold in the cell contents.
3. Answers will vary. Students probably will mention freezing, chemicals, drying, and other factors that might affect beet cell membranes.
4. Answers will vary. Such tests might be performed in the same manner as the heat test. The beet slice could be exposed to the factor being tested. Then it could be placed in a beaker of water to see if the red coloring leaks out. In each case, a second slice should be used as a control. This slice would not be exposed to the test factor, but would be placed in water to see if color leaks from the cells normally.

A Test Using Yeast Cells (page 53, one period)

Materials: 24 microscopes, 24 slides, 24 cover glasses, dry active yeast powder, water, 6 beakers, congo red stain.

The stain is prepared by dissolving 0.5 grams of congo red powder in 100 ml of distilled water. You probably will want to prepare yeast suspension for the class in one large beaker or flask. One package of dry active yeast powder should be stirred into a liter of water. Then small samples can be removed by individuals or small groups for testing. It will take four to five drops of stain for a milliliter of yeast suspension. Samples can be heated in test tubes or beakers, while unheated samples will serve as controls.

If your students have not seen yeast cells before, they probably will want to study a drop of yeast suspension with low and high power magnification, before adding the stain. Have them use a single drop of yeast on a slide covered with a cover glass. The same procedure is followed to observe the cells after heating. The heated cells will be killed and their cell membranes will be altered so that congo red can enter the cytoplasm and stain it. As a group, the unheated cells will remain colorless, because the membranes of living cells can keep the stain out. However, students may notice a few cells in the unheated group that do stain red. These, no doubt, are cells that have died for one reason or another. A count of such cells in a growing yeast culture can give information about the condition of the culture. That is, an investigator can tell if the culture is growing or dying out.

ANALYSIS QUESTIONS (page 54)

1. The heated cells stained red, while the unheated ones remained colorless. Apparently the cell membranes were altered by heating so that the stain could enter the cells and color them.
2. If any of the unheated cells absorbed stain, they must have been dead cells.

A Test You Can Plan (page 54, two periods)

Capable students probably will think of many other things that can be done to test the effects of environmental factors on yeast cell membrane activity. Besides testing the effect of freezing, they might want to test the effect of chemicals such as alcohol or various concentrations of salt. If you let them perform such tests, be sure to check their plans before allowing them to begin. It can be expected that some chemicals will alter the stain and invalidate the technique.

It is important to emphasize that only one factor should be tested at a time. That is, if cells were frozen and exposed to a chemical at the same time, the investigator could not tell whether observed results were due to freezing or the chemical. Also, every test should contain a control so that the investigator will have a standard with which to compare the results of the test. If heat is being tested, unheated cells serve as a control; if cells are frozen, unfrozen ones are used in the control.

ANALYSIS QUESTIONS (page 54)

1. Answers will vary.
2. Answers will vary. A control is needed to serve as a standard for comparing test results.

WORD MEANING (pages 54-55)

A

1. cell membrane—thin covering around a cell's cytoplasm
2. chlorophyll—green substance in certain plant cells
3. cytoplasm—outer and more fluid part of a cell
4. digestion—breakdown of food substances into simpler compounds
5. pellicle—thickened covering surrounding the cell of a paramecium
6. photosynthesis—process of using light energy to make foods

B

1. carbon dioxide—a waste product of life processes
2. chemosynthesis—process of food making without light energy
3. nucleus—control center of a cell
4. reproduction—production of new individuals
5. vacuole—cell structure filled with wastes or food particles
6. osmosis—passage of water molecules through a semipermeable membrane

SELF TEST (pages 55-56)

1. False. As some plants do move, it is better to distinguish plants from animals in terms of their cell structure.
2. True
3. False. Living things are often made up of thousands, millions, and trillions of cells.
4. False. The important life functions take place inside of cells.
5. False. Cells vary considerably in size and shape.
6. True
7. True
8. True
9. False. The faster-moving one-celled animals usually move by means of cilia.
10. True
11. True
12. True
13. True
14. True
15. True
16. False. A paramecium takes in food through a special mouth opening.
17. False. The contractile vacuoles of a paramecium function to remove excess water from the cell.

18. False. Animal cells do not possess chloroplasts.
19. True
20. False. The cell wall is considered to be a nonliving cell part.
21. True
22. False. Cell membranes are called semipermeable, because they allow only certain substances to pass through.

DISCUSSION QUESTIONS (page 56)

1. If the organism contained chlorophyll, or had cells with cell walls, and had no means of locomotion, it might be called a plant. If it lacked chlorophyll, as well as cell walls, and could move about, it might be called an animal. If the organism was not clearly either plant or animal, it might be classified as a Protist. The Protist Kingdom is discussed in Chapter 5.
2. The statement, "Cells are units of structure and function," means that living things are composed of cells, much as a brick wall is built of bricks. The activities of living things are carried on by cells. That is, a living thing can only do what its cells can do. Movement is a function of muscle cells or special cell parts. Food is made and stored in cells, and cells enable an organism to obtain energy from carbohydrates, remove wastes, grow, and reproduce.
3. Some cells may have special parts, such as cilia or flagella, for locomotion. Some have structures for taking in food or making food. They may have parts for storing food and removing wastes or excess water. Other cells have parts that function to protect the organism or capture food.
4. Motion can refer to movement of material within a cell, as when the chloroplasts of an *Elodea* cell move about. Locomotion is the action of a cell or organism that is moving from one place to another.
5. Food serves as a source of chemical compounds needed to build cell structures and to carry on vital chemical reactions. It also provides a source of energy for all of the life processes.
6. Food usually is obtained in the form of complex molecules that are insoluble in water. Before these molecules can be passed through cell membranes, they must be changed into simpler forms that can be dissolved in water. Thus, insoluble starch molecules are broken down into soluble simple sugar molecules. This is the function of digestion.
7. In simpler forms, some wastes such as carbon dioxide may diffuse to the outside through cell membranes. In more complex forms, carbon dioxide may be carried away by the blood and discharged by gills or lungs. Liquid wastes and excess water may be removed by contractile vacuoles or by kidneys, while solids may be discharged through special openings in cells or through the digestive canal.
8. Growth and repair are related, in that each usually involves the production of new cells and protoplasm. However, growth implies an increase in size, while repair is the replacement of worn or lost material.
9. When a cell divides, the nuclear membrane disappears and its contents duplicate themselves. One half of the nuclear material moves to each end of the cytoplasm. A new membrane appears around each mass of nuclear material so that two new nuclei are formed. Meanwhile, the cytoplasm is split in half, forming two daughter cells.
10. Both plant and animal cells contain protoplasm, both have nuclei and cytoplasm, and both have cell membranes. Plant cells often contain chlorophyll and have cell walls. Animal cells lack chlorophyll and cell walls. During cell division, the cytoplasm of animal cells constricts or is pinched in half between the newly formed nuclei. In plant cells a new cell wall forms be-

tween the nuclei, cutting the cell into two parts.

11. Animals depend on green plants for their food. Organisms that possess chlorophyll can trap the energy of sunlight and convert it into chemical bond energy, while animals obtain food by eating plants or eating animals that have eaten plants. Animals also depend upon green plants for an oxygen supply. Green plants release oxygen into the air as a by-product of the food-making process.
12. The cell membrane serves to contain the living material of a cell. It also acts to select those chemicals that enter or remain outside the cell and those substances that leave or remain inside.
13. Most nongreen plants lack chlorophyll and cannot manufacture food. Thus, they must obtain it from their environment, much as animals do. In many cases, food material is digested by chemicals released to the outside by the plant and later absorbed through the cell membranes. Various fungi obtain food by this means. Other nongreen plants, such as certain bacteria, can make food by chemosynthesis, which makes use of energy from chemical reactions rather than sunlight.
14. Plant tissue is generally harder and less flexible than animal tissue because of the presence of cell walls which are composed of the stiff, lifeless carbohydrate, cellulose. Animal cells often are surrounded only by a thin flexible cell membrane, although some of them have pellicles or coverings outside of the cell membrane.

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CHAPTER 4 The Organism

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Organisms vary in size, life span, and the number of cells in their bodies.	Observation of a Variety of Organisms, see Getting Started, Chapter 4, Teacher's Guide (p. 29) Things To Do, #1 (p. 77)
2. Tissues, Organs, and Systems	Although the cells of simple forms "shift for themselves," the cells of larger organisms depend on other cells for needed substances.	A Many-celled Alga (p. 61) Conjugation in Spirogyra (p. 125) Things To Do #3 (p. 77)
A. Cells and tissues	Cells vary in structure and function. Similar cells working together form a tissue.	Things To Do, #2 (p. 77) Things To Do, #4 (p. 77)
B. Tissues and organs	Groups of tissues working together form an organ.	
C. Organs and systems	Groups of organs working together form a system.	
3. Types of Algae	Some algae are single-celled. Others form many-celled filaments, or massive growths.	Things To Do, #5 (p. 77)
A. Collecting algae	Algae are common in fresh-water ponds and streams.	
B. Single-celled algae		
C. Algae from the sea	Seaweeds and rockweeds are forms of algae. The more complex algae have some cells that perform special functions.	
4. The Molds	Molds are fungi and cannot make their own food.	Bread Mold (p. 126) The Budding of Yeast Cells (p. 126)
A. Bread mold	The body of a mold is made up of branching, threadlike structures. Mature molds may reproduce asexually by forming spores. Some molds reproduce sexually when two special cells unite to form a zygote.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
5. Liverworts and Mosses	Liverworts and mosses are small, green plants found in moist places. Mosses are more complex than liverworts but less complex than seed plants.	
A. Liverworts		
B. Mosses		A Moss Plant (p. 65)
C. Reproduction in mosses	Mosses may reproduce both sexually and asexually.	
6. Structure and Functions of Hydra	Hydra has a single opening to its body cavity.	Hydra: A Simple Animal (p. 67)
A. Hydra's body wall	Hydra's body wall consists of two cell layers separated by a sheet of noncellular material.	
B. Division of labor	Hydra possesses primitive tissues.	
C. How hydra reproduces	Hydra reproduces asexually by budding, and sexually with egg and sperm cells.	
7. Earthworm Structure		An Earthworm (p. 71)
A. A life in the soil	Earthworms require moist soil. They deposit solid wastes at the ground surface, which aids plant growth.	Behavior of an Earthworm (p. 127) Things To Do, #7 (p. 77)
B. Internal systems	Earthworms have well-developed tissues, organs, and systems.	
Digestive system	The digestive tube has an opening at either end of the body.	Dissecting an Earthworm (p. 128)
Circulatory system	"Hearts" contract and maintain blood flow through blood vessels.	
Nervous system	The nervous system coordinates activities of the body systems.	
Reproductive system	Earthworms reproduce sexually.	

RELATED FILMS

Simple Plants: The Algae	11	Color	EBF
The Bryophytes	28	Color	McGraw
Stinging-Celled Animals: The Coelenterates	17	B&W Color	EBF
Segmentation: The Annelid Worms	16	B&W Color	EBF
The Hydra	11	B&W	UWF
Earthworms	11	Color	Dowling
Fungi	16	Color	EBF

OVERVIEW AND RATIONALE

Having studied the environment, the chemical aspects of the environment, and how simple plant and animal cells interact with environmental factors, the student is now introduced to some of the more complex organisms found in natural communities.

The way cells are organized into tissues, organs, and organ systems in the bodies of large plants and animals is described.

The alga, *Spirogyra,* is presented as an example of a many-celled plant, in which each cell "shifts for itself." This is followed by a discussion of the structure of several more complex plants including a seaweed, bread mold, liverworts, and mosses. Ways in which cells of these plants function illustrates division of labor. Included also are sections that develop the ideas of sexual and asexual reproduction in plants.

The last half of the chapter concerns structure of many-celled animals such as the hydra and earthworms. Once again, ways in which cells perform specialized functions are emphasized. The student is introduced to some of the major organ systems found in animals including digestive, circulatory, and nervous systems. Sexual reproduction in a hydra and earthworm is discussed.

GETTING STARTED

Chapter 3 focused attention on individual cells. Chapter 4 concerns the ways in which cells are organized in the bodies of organisms. One way to introduce this study is to have a variety of living things available for students to observe. Bread molds, green algae, mosses, liverworts, hydra, and earthworms are discussed in this chapter. You might add snails, clams, crayfish, eel worms, planarian worms, sow bugs, mushrooms, and various insects to the collection. Students may wish to bring individual specimens to class and care for them.

The important thing will be to study a number of different life forms and to raise questions about them. If enough specimens are available, each student can study one at a time, and students can trade back and forth. If the specimens are limited, divide the class into small groups and have each group work with a specimen.

As they observe each organism, students can describe how they think it carries on such life processes as movement, obtaining food, digesting food, obtaining oxygen, reproducing, and coordinating body activities. Ask them to consider how the cells might be arranged to make these processes possible. Students might also try to rank the organisms on the basis of apparent complexity in structure, and give reasons for the position assigned to each type.

This activity should be followed by a discussion, whose purpose may be to share observations and to raise questions about the organisms, stressing how they carry on life processes. Some of these questions may be answered by making further observations and others may be answered by consulting the textbook and references.

CHAPTER NOTES

Tissues, Organs, and Systems (page 59) When you discuss this section, you might want to mention a few other examples of organs and systems from familiar living things.

In a flowering plant, a root is an organ, and so is a stem or a leaf. The flower is made up of a group of organs. All of the stems and leaves of a plant taken together make up the shoot system.

In the human body, the digestive system is composed of the following organs: mouth, pharynx, esophagus, stomach, small intestine, liver, gallbladder, pancreas, and large intestine. The respiratory system is made up of the larynx, trachea, bronchial tubes, and lungs. Other major body organs include the skin, heart, spleen, kidneys, eyes, and ears.

Types of Algae (page 62) Although algae are discussed in this section as examples of simple multicellular plants, you may want to point out the great importance of this group. Algae of various types make up the primary food-producers in aquatic environments, including, of course, the oceans. The place of algae in such communities is discussed in more detail in later chapters.

The Molds (page 64) Be sure to emphasize the similarity between the structure of algae and fungi. Both kinds of organisms have simple bodies, lacking the familiar organs found in higher plants, such as true roots, stems, and leaves. However, algae are independent food-producing plants, while fungi are nongreen and must obtain food from the environment.

Liverworts and Mosses (page 66) Note that liverworts and mosses are more complex in structure than algae. Note also that, as a group, they are less dependent upon the water environment than the algae and may grow on the moist banks of streams. However, liverworts and mosses are not as well adapted to the land environment as the higher plants, in that they lack vascular tissue for transporting liquids, and they require a film of water for their reproductive process.

Structure and Function in Hydra (page 69) After discussing this section, and the section that follows, you might want to ask students to describe ways in which a hydra is adapted to the aquatic environment and the ways in which an earthworm is adapted to the land environment. Each of these animals has similar needs that vary with their environment. For example, a hydra may remain attached to some object and capture food particles that drift by, using its tentacles and stinging cells. An earthworm, on the other hand, burrows actively through the ground and relies on food particles obtained in the soil it swallows.

LABORATORY SUGGESTIONS

A Many-celled Alga (page 61, one period)

The purpose of this activity is to observe a plant made up of a colony of cells that function, for the most part, independently of other cells.

Materials: 24 microscopes, 24 slides, 24 cover glasses, *Spirogyra* culture.

Although *Spirogyra* is relatively difficult to culture in the classroom, it commonly forms silky threads on the surface of quiet freshwater ponds and lakes. It often grows into green mats which may cover the waters. The threads have a slippery feeling when rubbed between the fingers. Each cell contains a characteristic large ribbonlike chloroplast that forms a spiral. The chloroplast of one species forms a double spiral. If naturally occurring specimens cannot be found, a culture can be purchased from a biological supply house.

Students should mount a few short threads of algae in a drop of water and cover the specimens, with a cover glass. Along the spiral chloroplast are structures called pyrenoids; they contain starch which can be stained with iodine solution.

ANALYSIS QUESTIONS (page 62)

1. Except for the formation of spores, the cells of *Spirogyra* do not show a tendency toward division of labor. This statement is supported by the observa-

tion that the cells are generally similar in structure.
2. The green ribbonlike chloroplast is the food-making center. Chlorophyll accounts for the color of this part.

A Moss Plant (page 65, one-half period)

This activity will provide an opportunity to observe a plant made up of cells that exhibit division of labor.

Materials: 24 moss plants, 24 hand magnifiers.

Mosses and liverworts can be collected in places where the soil remains moist along streams, in gardens, and in greenhouses. When they are collected, a small quantity of soil should also be removed. Transport the specimens in wax paper or plastic bags. Be sure to keep them moist at all times. Low-power hand magnifiers will be helpful to students observing the leaves, protonema, buds and rhizoids. The soil can be removed by washing it gently away from the plant parts.

Some species have leaves thin enough to observe through the microscope. Students may want to prepare wet mounts and study the arrangement of cells in the leaves.

As described in the text, the leafy moss shoots reproduce by forming egg and sperm cells. These cells unite and produce a zygote, which in turn develops into a stalk with a capsule at the tip. Spores are produced in the capsule. Some of the plants in your collection may bear such stalks and capsules.

You will want to mention the similarity between the protonema of a moss and the threadlike structures of green algae such as *Spirogyra*.

ANALYSIS QUESTIONS (page 66)

1. The protonema and leafy shoots of the moss are food-making centers. This conclusion is based on the observation of green color due to chlorophyll in these parts.
2. Rhizoids of bread molds serve a function similar to those of mosses. Rhizoids also occur in liverworts and ferns.
3. Moss plants can be considered more complex than *Spirogyra* and bread molds, because the cells have a greater degree of division of labor.
4. Although the leafy shoot might dry up and die if the surface soil dried out for a period of time, the spores of the moss are more resistant to drying and might survive. When conditions are favorable, spores germinate into new protonemas.

Hydra—A Simple Animal (page 67, one period)

This activity involves observing a hydra, as an example of a simple animal that has some division of labor among its cells.

Materials: hydra, 24 watch glasses, 24 hand magnifiers.

Hydra may be found in clear, cool, freshwater ponds, lakes, and streams attached to aquatic plants, twigs that have been submerged, fallen leaves, or rocks. These animals usually are less than one inch in length and look somewhat like tiny bits of string with the end fibers separated. They often are gray or yellowish brown, although one species is green. When found, they should be collected together with some of the material to which they are attached and placed in an aquarium of pond water. They should be protected against rapid temperature changes and kept relatively cool—below 70°F. They can, of course, be purchased from biological supply houses. Students should have no difficulty seeing the parts described in the text. You might want them to compare the way hydra and paramecium carry on life processes.

If hydra is being watched under a microscope, it is sometimes possible to observe the discharge of stinging cells on the tentacles. This response can be stimulated by placing a drop of weak acetic acid along one side of the cover glass.

If hydra is touched with a dissecting

needle or toothpick, it will respond by contracting. Students may be interested to see how long it takes for the organism to extend itself again, after such a response.

Students also might be interested to see if they can produce any response in an extended hydra by causing a shadow or a bright light to fall on it.

ANALYSIS QUESTIONS (page 69)

1. The base, the body column, and the tentacles each have special cell types which show a definite division of labor.
2. Hydra can move about, use its tentacles, and contract and expand its body. These actions suggest the presence of musclelike cells.
3. Solid wastes that accumulate in the body cavity must be removed through the mouth, as it is the only opening.

An Earthworm (page 71, one period)

This exercise provides an opportunity to study the external anatomy of an animal whose cells are organized into tissues, organs, and systems. It also can serve as the first of a three part investigation, when followed by Behavior of an Earthworm (page 127) and Dissection of an Earthworm (page 128).

Materials: 24 living or preserved earthworms, 24 low power magnifiers.

Earthworms usually can be found by digging in moist loamy soil. On damp nights they can often be found on the surface of grassy lawns. Here they can be collected easily by using a pail and flashlight. They should be kept in containers with a few inches of moist soil, rich in organic material, such as peat moss. However, be sure to avoid excessive moisture.

Students should have no difficulty locating the structures described in the text—segments, mouth opening, anal opening, and setae. A low-power hand magnifier will be helpful. The short bristlelike setae can be felt by moving the fingers along the side of the worm. These setae act as anchors as the worm moves along. The pinkish color of the body is due primarily to hemoglobin in the blood of the skin capillaries. The dorsal blood vessel that runs along the back of the worm can be seen to contract from time to time, as it pumps the blood.

The bandlike thickening on the body wall is called the clitellum and functions to secrete a cocoon, in which eggs are layed after mating. However, some species do not have a clitellum. Most of the pores that open through the body wall function in waste removal. A few pores serve to discharge or receive reproductive cells. Others are entrances to reproductive cell receptacles.

ANALYSIS QUESTIONS (page 72)

1. Earthworms and their relatives are called segmented worms, because their bodies are made up of a series of ringlike sections.
2. Large numbers of earthworms would not be expected to occur in soil that contains little or no organic material, because earthworms rely on such material for food.
3. Earthworms obtain oxygen from the air through their body surfaces. The red pigment, hemoglobin, in the blood of the skin capillaries, aids in the transport of oxygen to all body cells.

WORD MEANINGS (page 75)

A

1. algae—simple green plants
2. egg cell—female reproductive cell
3. embryo—a developing organism
4. fungi—nongreen plants
5. organ—a group of tissues working together
6. plasma—blood fluid
7. sperm—male reproductive cell
8. system—a group of organs working together

B

1. tissue—a group of cells of the same type

2. zygote—a structure formed when male and female sex cells unite
3. fertilization—process by which two reproductive cells unite
4. invertebrate—animal without a backbone
5. nerve cell—type of cell that carries messages
6. ovary—female reproductive organ
7. testis—male reproductive organ
8. clitellum—bandlike structure on the outside of an earthworm's body

SELF TEST (page 75-76)

1. True
2. True
3. True
4. False. Muscle cells can only pull as they contract.
5. False. Tissue cells are quite dependent on other kinds of cells.
6. False. Cells of a hydra better illustrate division of labor than cells of a paramecium.
7. True
8. True
9. False. *Spirogyra* is an example of a many-celled alga.
10. True
11. False. Rockweed belongs to the plant group called algae.
12. True
13. False. Bread molds lack chlorophyll.
14. True
15. False. Reproduction by asexual spores is an example of asexual reproduction.
16. False. Mosses are considered to be more complex than algae.
17. True
18. False. A zygote is formed when fertilization takes place.
19. True
20. False. A hydra only has a mouth opening.
21. True
22. False. Ovaries produce egg cells.
23. False. An egg and a sperm cell unite to form a zygote.
24. True
25. True
26. False. Earthworm blood plasma contains a red pigment.
27. True
28. False. An earthworm has both female and male sex organs.

DISCUSSION QUESTIONS (pages 76-77)

1. Generally, the cells of larger organisms are not much larger than those of smaller forms, but are present in greater numbers. This can be demonstrated by observing prepared slides of frog or mouse tissue and comparing the cell size with that of human cells.
2. In the statement, "The cells of a large plant or animal must depend upon other cells to provide them with the essentials of life," *essentials of life* refers to needed molecules of such things as food and oxygen, as well as maintaining a favorable environment that is low in waste materials and free of parasites.
3. Muscles are made of muscle cells that produce movement by contracting or becoming shorter and thicker. When they relax, they assume their original form. Thus, muscles can pull, but they cannot push. In order to push against something, a lever system usually is employed. For example, when we push against an object, our muscles are pulling on bones of the skeleton which in turn act as levers.
4. Gland tissue, muscle tissue, and nerve tissue are alike in that they are composed, in each case, of a group of similar cells performing similar functions. They differ, however, in the specialized functions performed. Gland tissue secretes specific chemical substances. Muscle tissue makes movement possible, and nerve tissue carries "messages" needed to coordinate activities within the organism.
5. A single-celled organism is a "jack-of-all-trades" in that it must carry on all the life functions by itself.
6. "Division of labor" refers to specialization of cells in multicellular forms. In-

stead of each cell performing all life processes equally well, certain cells are adapted for special functions, which benefit the whole organism. In the human, cells of the digestive canal process food, cells of the blood transport oxygen, cells of the kidneys extract waste chemicals from the blood, muscle cells make movement possible, and nerve cells help to coordinate these actions.

7. Algae and fungi are similar in being relatively simple organisms with cells commonly arranged in threadlike filaments. They demonstrate only limited specialization. Fungi are nongreen plants, while algae contain chlorophyll.
8. Both algae and fungi grow by cell division and cell enlargement. Algae obtain food by photosynthesis, while fungi must digest and absorb food from the environment. A threadlike alga, such as *Spirogyra*, may reproduce asexually by having sections broken off, which then grow into separate filaments. *Spirogyra* also may form special reproductive cells which unite to form a zygote. The zygote develops a protective case, and from this structure a new filament can grow. Fungi like bread molds may reproduce asexually by forming specialized cells called spores. These are released from the parent plant and can germinate into new molds. Bread molds also reproduce by forming primitive sex cells. These unite and the resulting zygote develops sexual spores.
9. In sexual reproduction, there is a fusion of nuclei from two sex cells. In asexual reproduction, there is no prior union of cells. Consequently, there is only one parent in the case of asexual development.
10. Although some algae may grow in water supplies and produce a bad odor and taste in the water, other forms provide food, as well as fertilizers, and a supply of certain chemicals such as iodine. But more important, algae are the primary food producers in the sea, in freshwater lakes, and streams. Thus, most other forms of aquatic life are basically dependent upon algae. Some fungi cause diseases in plants and animals, including man. Ringworm and athlete's foot are examples. But other forms provide food (mushrooms) and drugs (penicillin). Many fungi act to cause the decay of dead organisms and thus return vital chemicals to the air and soil.
11. Since algae are green plants and require sunlight to manufacture food, their growth can be prevented by reducing the light that reaches them. Also, there are chemicals available, such as copper sulfate, that act on algae to prevent their growth.
12. Growth refers to an increase in size and quantity of protoplasm present in a living thing. Reproduction involves producing an offspring.
13. Mold spores usually can be stimulated to germinate by providing moisture, a suitable food substance, a favorable temperature, and a supply of air.
14. A moss plant begins life as a spore. If conditions are favorable, the spore germinates, giving rise to a protonema. This in turn forms buds and rhizoids. The buds form stems and leaves, while the rhizoids grow into the soil, functioning to hold the plant in place and absorb water. Sex cells are formed at the tips of the stems. Sperm cells from one stem fertilize the egg cells of other stems. The resulting zygotes grow into structures that develop and release spores.
15. In the simpler algae, each cell "shifts for itself" and tissues, as such, are not present. In the higher algae, like rockweed, some cells group to perform special tasks in the holdfasts and floats. Thus, primitive types of tissue are formed. Mosses are even more complex and possess definite tissues. In hydra, the cells show partial division of labor, and primitive or partially

formed tissues exist. An earthworm has well-developed tissues. The holdfast of the rockweed and the tentacles of hydra might be called primitive organs. In the moss, the stems, leaves, and sex cell producing parts can be called organs. An earthworm has well-defined organs, such as the pharynx, esophagus, crop, gizzard, and intestine, which make up the digestive system.

16. An earthworm is more complex than a hydra, in that it has well developed tissues, organs, and organ systems. These system include the digestive, circulatory, excretory, muscular, and nervous systems.
17. The burrowing activities of earthworms benefit plants. The worms burrow through the soil and bring up particles from beneath the surface. The burrows allow rain water and air to enter the soil, and this aids plant root growth. Earthworms also serve as food for certain animals.

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CHAPTER 5 Plant and Animal Diversity

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Many different kinds of plants and animals exist in the world today	Key to animal groups, see Getting Started, Chapter 5, Teacher's Guide, p. 39 The Use of Keys (p. 106)
2. A Confusion of Names	Common names are confusing because they vary from place to place.	Things To Do #2 (p. 103)
A. The scientific name	Misunderstandings can be avoided by use of scientific names. Scientific names reflect relationships among organisms. The scientific name is made up of the genus and species names.	Things To Do #4 (p. 103)
B. Classification groups	No two organisms are exactly alike. Variation exists within groups. The Linnaean system is composed of groups within groups.	Individual Differences (p. 81) Things To Do # 1, 6 (pp. 103, 104)
3. Animal Phyla		Things To Do #3, 5 (p. 104)
A. Vertebrates	Vertebrates are animals with backbones. This group includes mammals, birds, reptiles, amphibians, bony fish, sharks and rays, and lampreys. The body temperature of warm-blooded forms is not affected by the surrounding temperature, while that of cold-blooded forms varys with the outside temperature.	
B. Arthropods	Arthropods are invertebrates with segmented bodies and jointed legs. This group includes arachnids, insects, and crustaceans.	
C. Echinoderms	Echinoderms are sea forms that have body walls with	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	hard plates and spines.	
D. Mollusks	Mollusks have soft bodies that often are protected by hard outer shells or have rodlike internal supports.	
E. Segmented worms	The segmented worms have bodies divided into sections.	
F. Roundworms	Roundworms have elongated cylindrical bodies that are not segmented.	
G. Flatworms	Flatworms are flattened in form and have no anal openings.	
H. Coelenterates	The coelenterates have simple digestive cavities with a mouth as the only opening.	
I. Porifera	Sponges are animals with a plantlike appearance. They live in water attached to some object and secrete hard parts for body support.	
J. Protozoa	Protozoa are singled-celled invertebrates.	
4. Plant Phyla		Vascular Tissues (p. 99)
A. Vascular plants	Vascular tissue carries liquids from one plant part to another.	
	The vascular plants include flowering plants, cone-bearing plants, ferns, and horsetails.	Bacteria and Molds (p. 129)
B. Mosses and liverworts	These green plants live in moist places close to the soil and have no vascular tissue.	
C. Higher fungi	Fungi have no chlorophyll and must obtain food by feeding on the bodies of other organisms.	
D. Algae	Algae are green plants that live in water or moist places and consist of single cells or many cells in filaments or massive growths.	
5. Protist Kingdom	The classification system is revised from time to time, taking new information into	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	account. Some organisms are borderline and do not fit well into either the plant or animal kingdom. It has been suggested that a third kingdom be formed to include such borderline organisms.	
A. Bacteria	Bacteria are single-celled, usually lack chlorophyll, and have no organized nuclei.	The Growth of Bacteria (p. 129)
B. Blue-green algae	Blue-green algae are single-celled forms with chlorophyll but no chloroplasts and have no distinct nuclei.	
C. Sporozoans	Sporozoans are single-celled parasites that reproduce by means of spores and have no means of locomotion.	
D. Other borderline types	Various other borderline types may be classified as protists.	
6. Viruses	Viruses are disease causing substances that have characteristics of both living and nonliving material. They are exceedingly small and reproduce only when they are inside living cells.	

RELATED FILMS

	Min.		
Simple Plants: Bacteria	13	Color	COR
Between Living and Non-Living	29	B&W	IU
Angiosperms: Flowering Plants	21	B&W Color	EBF
Gymnosperms	17	B&W Color	EBF
Life Story of a Fern	16	B&W	UWF
Single-Celled Animals	17	B&W Color	EBF
Flatworms	16	B&W Color	EBF
Adaptive Radiation—The Mollusks	18	Color	EBF
The Jointed-Legged Animals—Arthropods	19	B&W Color	EBF

OVERVIEW AND RATIONALE

Chapter 5 concerns the great variety of life forms found in nature, and explores the problem of grouping or classifying living things. It also introduces the major groups of plants and animals, whose roles in the natural community will be investigated in Block II.

The Linnaean system of classification is discussed in detail. How every organism can be grouped in a kingdom, phylum, class, order, family, genus, and species is described. Differences, as well as similarities, are shown to exist among related forms.

Each of the major animal groups is presented together with the important subgroups. Thus mammals, birds, reptiles, amphibians, bony fish, sharks and rays, and lampreys are discussed as vertebrates. This is followed by a consideration of arthropods, echinoderms, mollusks, segmented worms, roundworms, flatworms, coelenterates, sponges, and protozoans. The major plant groups are reviewed in a similar fashion. These include vascular plants, mosses and liverworts, higher fungi, and certain algae.

The last part of the chapter deals with the protist group, including bacteria and various other borderline organisms. Attention also is given to the structure and behavior of viruses.

GETTING STARTED

Since Chapter 5 concerns the problem of classifying living things, you might introduce this topic by asking your students to "classify" a group of familiar objects. To do this, place a variety of things in shoe boxes or other suitable containers. Such things as nuts, bolts, nails of various sizes, paper clips, pens, pencils, pins, rubber bands, pieces of different kinds of paper, and different kinds of wood make an interesting collection. A box for every couple of students should be enough. Ask them to organize each collection into groups of similar things. For each group, they should list the characteristics or traits that the members of the group have in common. For example, nails have sharp smooth ends while bolts have flat threaded ends. Then have the students see if they can form larger groups based on other characteristics. Bolts and nails might be grouped together, because they are made of metal, while all the paper items can be assigned to another group.

The methods used by students to group objects can be related directly to the methods biologists use to classify living things, for both methods are based primarily on similarities in structure.

You also can relate this experience to the idea that there is more than one way to group objects, just as there may be more than one way to classify living things. Objects can be grouped according to function rather than structure or composition. That is, wood blocks and paper might be grouped together based on composition, or wood blocks might be grouped with nails as building materials. Similarly, some biologists classify bacteria as plants, while others prefer to place them in the Protist Kingdom.

CHAPTER NOTES

A Confusion of Names (page 79) On page 106 is an explanation and example of a classification key. After reading this example, students may want to prepare a key for the objects they grouped earlier. This can be followed by an activity involving the use of a key to classify specimens. These can be living or preserved specimens, or simply pictures of various forms. A simple key to the major animal phyla is provided below. Other more detailed keys for living things common in your locality probably are available in reference books and laboratory manuals. Students can utilize such keys to classify and label specimens in the classroom or specimens in individual collections.

In discussing scientific classification, you might want to indicate the problem facing biologists as they try to group living things. Many new kinds of organisms are being described every year. It is estimated by some workers that at least 2,000,000 kinds of living things exist today. To make order out of such a large group is a tremendous problem, yet biologists throughout the world must agree upon what name to use for each kind of plant and animal. Otherwise, they are un-

Key to the Major Animal Phyla

1A	Body made up of one microscopic cell or a colony of similar cells	Protozoa
1B	Body made up of many cells; usually visible to the unaided eye	2
2A	Body wall pierced by many pores	Porifera
2B	Body wall without pores	3
3A	Body with one opening to the digestive canal	4
3B	Body with two openings to the digestive canal—mouth and anus	5
4A	Body cup or saclike	Coelenterata
4B	Body flattened	Platyhelminthes (flatworms)
5A	Body wheellike with a center and no distinct right or left side	Echinodermata
5B	Body not wheellike; has a definite left and right side	6
6A	A wormlike organism	7
6B	Not wormlike	8
7A	Body composed of many similar sections	Annelida (segmented worms)
7B	Body not segmented	Nematoda (roundworms)
8A	Body soft, with an external shell or an internal rodlike support	Mollusca
8B	Body with a hard covering of chitin or with a skeleton of bone or cartilage	9
9A	Body covered with chitin; no internal skeleton; appendages jointed	Arthropoda
9B	Body with an internal skeleton of bone or cartilage	Chordata

Key to the Major Classes of the Phylum Arthropoda

1A	With feelers or antennae	2
1B	Without feelers; four pairs of legs	Arachnida
2A	Two pairs of feelers; five pairs of legs or more	Crustacea
2B	One pair of feelers	3
3A	Three pairs of legs	Insecta
3B	More than three pairs of legs	4
4A	One pair of legs on most segments	Chilopoda
4B	Two pairs of legs on most segments	Diplopoda

able to communicate with each other and share information about particular organisms.

It should be emphasized that, although the modern system of classification is based upon Linnaeus' system, changes have been made and continue to be made in the way living things are grouped. Some workers tend to classify organisms in a relatively small number of large groups, while others prefer to subdivide groups into smaller and smaller categories. As a result of the latter activity, students may discover reference to a subphylum within a phylum, or a subspecies within a species.

Students may also be interested to know that a species may consist of a group of similar organisms that are able to produce fertile offspring. Thus, the members of the species of domestic cats can produce offspring that, in turn, can reproduce. However, even though a donkey and a horse can produce an offspring called a mule, this offspring is not capable of reproducing. For this and other reasons, the donkey and the horse are assigned to different species.

The Animal Phyla (page 83) You might want to mention that zoology textbooks will commonly discuss 20 or more phyla of animals, while in this book only a few of the more important groups are included. You also might note that vertebrates usually are considered to make up a subphylum of the Phylum Chordata.

The Protists (page 96) Emphasize that the idea of the Protist Kingdom is a relatively recent one, and that there is much discussion today among biologists concerning the composition of this group. Some workers assign those groups discussed in this section to the new kindgom, while others include all of the algae and fungi, as well.

The Viruses (page 98) Having completed the section dealing with the problem of separating living things into distinct groups—plants, animals, and protists—students may be interested in discussing the problem of separating the two groups, living things and nonliving things. This will be a good time to review the life processes, described in Chapter 2. Viruses act like living things in that they can reproduce under certain conditions, but they do not seem to require food in their inactive state, and they do not seem to possess enzymes.

LABORATORY SUGGESTIONS

Individual Differences (page 81, three periods)

This series of three activities demonstrates that living things of the same kind vary. Seeds vary in length and the time it takes to sprout. Humans vary in their reaction time. Thus, even when living things are placed in the same species, we can expect to observe differences among them.

Variation in Bean Seeds (page 81, one period)

Materials: lima beans, 24 millimeter rules.

Lima beans are suggested because they are large seeds. But any seed large enough to handle easily is suitable for this study. Have students measure each seed to the nearest millimeter, rather than to estimate fractions of millimeters. If time permits, they may want to measure variation in other seed characteristics such as weight, which should be measured to the nearest tenth of a gram, or volume measured to the nearest milliliter. Volume can be determined by displacement of water in a graduated cylinder. Variation also may be noted in seed coat color, pattern, and texture.

After the data have been collected, capable students may want to plot them on graph paper. Have them use length in millimeters as units for the horizontal axis, and number of seeds in each size group as units for the vertical axis. The resulting curve probably will be "bell-shaped."

Sprouting Some New Plants (page 81, one period)

Materials: corn seeds, soil, and 12 planters.

Corn seeds are suggested because they sprout quickly at room temperature and provide a plant whose height is easily measured. Other kinds of seeds can be used if corn is not available.

It is a good idea to soak the seeds in water overnight before planting them. Soaked seeds usually sprout sooner than those planted dry. A pan about two inches deep or a wooden flat can be used as a planter. Seeds should be planted about an inch below the surface of soil, sand, or vermiculite. Place them about three inches apart and in rows so that they can be identified and so that they can be measured individually.

The soil must be kept moist, but not muddy. Cover the planter with plastic sheeting or a moist paper towel to reduce evaporation until the seeds have sprouted. Corn should sprout in three to five days. Each day during the sprouting period, students should record the total number of plants that have appeared. This will demonstrate variation in a physiological process—sprouting. At the end of three weeks, each plant's height should be measured to the nearest millimeter. This will demonstrate variation in height. Other characteristics that vary may be noted, such as the number of leaves produced, size of leaves, color of stems, etc.

ANALYSIS QUESTIONS (page 82)

1. Answers will vary.
2. A random sample of lima bean seeds would be expected to show differences in weight. This could be demonstrated by weighing a number of seeds and recording their individual weights to the nearest tenth of a gram.
3. Answers will vary.
4. Answers will vary.
5. When dealing with a group of organisms that vary in the characteristic being studied, any one measurement cannot be thought of as better than any other. So instead of dealing with individual measurements, the average is useful as representative of the whole group.

Human Reaction Time (page 82, one period)

Materials: 12 rules.

Students should be cautioned to position the rule each time at the same distance above the fingers of the subject. Otherwise, the measurements will not be comparable. Capable students may be interested in graphing the data collected. To do this have them average the trials for each individual tested. The averages will be in units of "inches the rule dropped." These can be rounded off to the nearest inch, and plotted on graph paper, using inches the rule dropped on the horizontal axis and number of individuals whose average falls in each group as the units of the vertical axis. To make the graph more interesting, have students share data so that each has 30 or 40 averages from different individuals to plot.

ANALYSIS QUESTIONS (page 83)

1. The data will indicate that people vary in reaction time.
2. Answers will vary.
3. Answers will vary.

Vascular Tissues (p. 99, two periods)

These two activities demonstrate some of the properties of the ducts in vascular plant tissue. The first shows how water, stained a dark color, rises slowly in a celery stem, and how the ducts can be identified in a stem cross section. The second illustrates the effect of various concentrations of salt solution on the functioning of the ducts.

The Rise of Liquid in a Celery Stalk (page 99, one period)

Materials: celery, staining material or ink, 12 razor blades, 12 glass containers.

Celery is suggested for this demonstration because it has a soft stem with relatively large ducts. Students may want to repeat this experiment on other types of soft stems to see if similar results can be obtained. The stem should stand in an inch of water in a small container. Beakers or baby-food bottles work well. Food coloring, as well as a laboratory stain or ink, can be used to stain the water. It is important, in either case, to stain it darkly, otherwise the color cannot be seen in the ducts.

Students, of course, should be warned to handle the razor blades or knives carefully.

Capable students may be interested in calculating how fast the water rises in the ducts. They can do this by keeping track of the time and measuring how far the stain travels. To go even further, they may want to see if changing the temperature or light conditions affects the rate at which liquid rises in the stem.

Similar demonstrations can be performed on fleshy roots such as a carrot.

ANALYSIS QUESTIONS (page 99)

1. The ducts in the celery stalk are located in a line along the outer edge of the stem, while in corn they are scattered throughout the stem cross section. This can be demonstrated by placing a young corn stem in colored water.
2. The duct cells appear larger than the cells around them.

Another Experiment with Celery Stalks (page 100, one period)

Materials: celery, 5% and 10% salt solution, 5% and 10% sugar solution, stain or ink, 12 glass containers.

The 5% and 10% solutions can be prepared by putting 50 and 100 grams of solid in separate containers and adding enough water to make a liter of each solution.

Once again, it is important to stain the solution darkly, so that the color can be detected when it reaches the top of the test pieces. Results can be expected within a class period. The stain will reach to top of the stalks in water first and those in the 5% solutions sometime later. It is doubtful if it will ever reach the top of the stalks in the 10% solutions. In fact, these stems will become wilted. The results can be explained in terms of osmosis. Water moves through a semipermeable membrane from the side where it is more concentrated to where it is less concentrated. In the water, the water concentration is high on the outside of the stem, so water enters the stem. In the 10% solution, the water is more concentrated inside the stem, and as a result water leaves the stem. This explains the wilting.

ANALYSIS QUESTIONS (page 101)

1. Both salt and sugar solutions slowed the movement of stained water into the vascular system.
2. Judging from the results, it can be concluded that sugar could not be fed to plants, if the sugar concentration remained high on the outside of the plant tissue.
3. Salt can serve as a weed killer by lowering the water concentration on the outside of the plant, so that water leaves the plant tissue. This could create a problem if other plants were growing nearby, because they too would probably be affected.

WORD MEANINGS (page 101)

A

1. genus—first part of a scientific name
2. protist—includes the protozoa
3. species—one kind of living thing
4. variation—differences among members of a group
5. vertebrates—animals with backbones
6. viruses—have characteristics of living and nonliving things

B

1. amphibians—cold-blooded vertebrates without scales or plates
2. arthropods—invertebrates with jointed legs
3. birds—skin with feathers
4. mammals—have skin with hair
5. mollusks—have soft bodies, often with a hard covering like a clam
6. reptiles—skin covered with dry scales

SELF TEST (page 101-102)

1. False. Nonscientists generally are not agreed on what names to use for living things.
2. False. In the scientific name for the cat, *Felis* is the genus name and *domestica* is the species name.
3. True
4. True
5. False. More variation is expected among members of a phylum than among members of an order.
6. True
7. True
8. False. Birds are warm-blooded animals.
9. False. Reptiles have dry skin covered with scales or plates.
10. False. Catfish, bass, and trout are placed in the group called bony fish.
11. True
12. True
13. False. Members of the starfish group all live in the sea.
14. True
15. False. Roundworms have two openings to their digestive canals, while flatworms usually have one, though some flatworms do not have digestive canals.
16. True
17. False. Sponges occur in fresh water as well as in the sea.
18. False. Vascular plants are believed to be more complex than nonvascular plants.
19. False. Mosses do not have true vascular tissues.
20. False. Algae do not cause decay.
21. False. Brown algae can produce their own food because they have chlorophyll.
22. True
23. False. Viral particles are smaller than bacterial cells.
24. True

DISCUSSION QUESTIONS (pages 102-103)

1. Early men were interested in plants and animals primarily as a source of food and material for shelter. Parts of plants and animals were used as tools, clothing, and jewelry. They also were interested in organisms that were dangerous to their well-being.
2. Scientific names make it possible for people to communicate accurately about plants and animals and to avoid misunderstandings.
3. Biologists believe that the structure of living things can be used as an indication of relationships. Thus, organisms that have many characteristics in common, such as a head, eyes, and cestry. Since classification of living things is based on grouping together those organisms with similar appearances, those placed in a genus or family group are probably more closely related than those in different genera or families.
4. Due to differences in heredity and environment, humans vary in almost every characteristic. For example, they vary in height, weight, rate of growth, intelligence, eye color, reaction time, blood type, and other factors. Although they have the same heredity, identical twins may vary in height, weight, intelligence, and other characteristics influenced by the environment. They will not vary, however, in those traits due strictly to heredity such as sex, eye color, and blood type.
5. Grasshoppers and polar bears have certain general body parts in common, such as a head, eyes, and legs used for locomotion. They are animals and they cannot make food. They have cells that lack cell walls. But they have much more in common when considered as living things. Each is able to carry on the life processes, such as food getting, digestion, respiration, circulation, excretion, and reproduction.
6. Plants, like animals, can be expected to vary in almost every trait. They vary in height, rate of growth, color, shape of leaves, number of flowers,

and ability to resist drying. Seeds also vary in such things as size, shape, and time of sprouting.

7. Warm-blooded animals can remain active and seek food or defend themselves even when the temperature is low. Cold-blooded forms become inactive and immobile in cold weather. However, to maintain a high body temperature in cold weather requires a large quantity of food, even when it may be in low supply. Under similar conditions, the cold-blooded form requires less food to maintain its inactive life.
8. Members of the amphibian and reptile classes are cold-blooded animals that have many structures in common. Some members of each group have long, thin bodies and short legs. However, they can be distinguished by the fact that the skin of reptiles is covered with dry scales and plates, while that of the amphibians is moist and lacks scales and plates.
9. The term "fish" is confusing, because it may refer to bony fish or cartilaginous fish, like sharks and rays. There also are starfish, shellfish, and silverfish that really are not fish but members of invertebrate groups. The term "worm" may refer to animals in three different phyla. People also use the word to describe various insect larvae and other animals that are not worms.
10. Spiders are arthropods with two distinct body regions and eight legs. Insects are arthropods with three body regions and six legs.
11. Arthropods may be called the dominant animals, because there are far more different kinds of them than of all other animal groups added together. Insects make up the largest class of arthropods and they compete effectively with man for food. On the other hand, mammals are generally the largest animals, and man with his superior brain has the ability to think.
12. Insects are numerous, because they have a high reproductive rate and a short generation time. They are adapted to a wide variety of habitats and types of food. They also profit by their small size which makes it possible for them to take refuge where larger animals could not find cover.
13. The seed of a flowering plant develops in the ovary of a flower. The ovary becomes part of the fruit which contains the seed. In cone-bearing plants, the seed develops freely exposed on the surface of the cone scales.
14. Nonvascular plants generally are small plants restricted to moist areas. Water is absorbed from the surroundings by individual cells and passed to other cells by osmosis.
15. One could argue that by destroying all bacteria many diseases could be eliminated and the spoilage of food and decay would be largely controlled. This argument, however, ignores the important role of bacteria in the biological community. Bacteria serve as food for many microscopic forms, return needed materials to the soil by decaying the bodies of dead plants and animals, and are used by man in many important industrial processes.
16. Viruses are like living things in that they can reproduce, and because they undergo hereditary changes. They are like nonliving things when outside of host cells. Here they become inactive and carry on none of the familiar life processes.
17. The third kingdom, Protista, seems necessary to classify the many borderline organisms that do not have either distinct plant or distinct animal characteristics.
18. Over a period of countless years, some groups have become adjusted to conditions in the sea. Their body parts and patterns of behavior are adapted to the marine environment and such adaptations are not fitted to the different physical and biological factors of a freshwater or a land community.

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BLOCK I Laboratory Investigations

THE CHAPTER AT A GLANCE

INVESTIGATION	PURPOSE	RELATED CHAPTERS
Part I—Books and Instruments		
1. Reference Books and Guides (p. 105)	Locating information	Chapter 1
2. The Use of Keys (p. 106) A. How to use a simple key	Identifying an organism by use of the classification key	Chapter 5
3. Biological Equipment (p. 106)		Chapter 1
A. Instruments and glassware	Name and uses of simple laboratory equipment	
4. Collecting and Culturing (p. 108)		
A. Materials for field collecting	Names and uses of simple field equipment	Chapter 1
B. Collecting a pond culture	How to collect pond specimens	Chapter 1
C. Cultures in the laboratory	How to maintain specimens in the classroom	Chapter 3
5. Preserving Specimens (p. 111) A. Preserving in alcohol B. Preserving in formalin	Methods for preserving specimens	Chapter 1
6. Raising Plants (p. 111)	How to sprout seeds and maintain plants in the classroom	Chapter 5
7. Use of the Microscope (p. 112) A. Care of the microscope B. Using the microscope	Care and use of the microscope	Chapter 3
8. Use of a Simple Projector (p. 113)	Care and use of a microprojector	Chapter 3
9. Temporary Microscope Mounts (p. 114) A. Making a cross section B. Staining a cross section	Preparation of microscope slides and staining technique	Chapter 3

INVESTIGATION	PURPOSE	RELATED CHAPTERS
Part II—Demonstrations and Experiments		
1. Physical Factors of the Environment (p. 115)		Chapter 1
A. Sunlight and plant growth	To test the effect of varying amounts of sunlight on sprouting bean seeds	
B. High temperature and life	To test the effect of boiling water on microscopic pond organisms	
2. Carbon Compounds (p. 116)		Chapter 2
A. A chemical change that releases carbon	To demonstrate that carbon is a common element in plant and animal material	
3. Radioactive Substances (p. 117)		Chapter 2
A. How you can detect radioactivity	To demonstrate the use of a radiation detector	
4. Living Membranes (p. 118)		Chapter 3
A. An osmosis demonstration	To demonstrate the movement of water through a nonliving semipermeable membrane	
B. Osmosis in a carrot	To demonstrate osmosis using the living membranes of carrot root cells	
5. Behavior of paramecium (p. 121)		Chapter 3
A. A reaction to eosin	To test the effect of eosin on paramecium	
B. Fission in paramecium	To observe reproduction of paramecium	
6. Stored Starch in Green Leaves (p. 122)		Chapter 3
A. Testing for starch in green leaves	To demonstrate that light is needed for starch production in green leaves	
7. Discharge of Oxygen by an **Elodea** Plant (p. 123)		Chapter 3
A. Collecting oxygen under water	To demonstrate gas production by a green plant	

INVESTIGATION	PURPOSE	RELATED CHAPTERS
8. Plant Pigments (p. 124)		Chapter 3
A. Separating plant pigments	To demonstrate the presence of pigments in green leaves	
9. Conjugation in **Spirogyra** (p. 125)		Chapter 4
A. Special spore cells	To observe **Spirogyra** cells in various stages of conjugation	
10. Bread Mold (p. 126)		Chapter 4
A. Observation of bread mold	To observe the structure of bread mold	
11. The Budding of Yeast Cells (p. 126)		Chapter 4
A. Reproduction of yeast cells	To observe yeast cells reproducing by budding	
12. Earthworms (p. 127)		Chapter 4
A. Behavior of an earthworm	To observe the behavior of an earthworm and its response to certain physical factors	
B. Dissecting an earthworm	To observe the internal structure of an earthworm	
13. The Growth of Bacteria (p. 129)		Chapter 5
A. A culture of bacteria	To culture and observe some decay bacteria	
B. Staining bacteria	To demonstrate the technique of staining bacteria	
14. Bacteria and Molds (p. 129)		Chapter 5
A. Bacteria, molds and decay	To demonstrate methods for culturing microoganisms	

INVESTIGATION	PURPOSE	RELATED CHAPTERS
Part III—Study of a Pond Community		
1. Selecting a Community for Investigation (p. 131)	To select a suitable community to study	Chapter 1
A. Mapping	To prepare a map of the area indicating its obvious features	
B. Plotting physical conditions	To observe light, heat, and other physical factors present in the area	
2. Populations of the Community (p. 132)	To discover what organisms are present	Chapter 1
A. Survey of plants and animals	To observe the locations, numbers, and activities of larger forms	
B. Collecting small organisms	To collect and culture small forms	Collecting and Culturing (p. 108)
C. Classifying forms observed and collected	To identify some of the organisms	Chapter 5; The use of keys (p. 106)
D. Preserving specimens	To observe certain forms for later study	Preserving specimens (p. 111)
3. The Roles of Community Members (p. 133)	To determine the role of various members in the community	
A. Detailed study of a single life form	To study the role of one member in detail, making use of available reference materials	Chapter 3, 4; Reference books and guides (p. 105)
B. Pyramid of numbers	To determine the relative numbers and kinds of organisms within the community	
4. Interaction Between Community Members and the Environment (p. 134)	To test the effect of light on the members of a pond community	Chapter 1; Physical factor of the environment (p. 115)
5. Effects of Temperature Change (p. 134)	To test the effect of different temperatures on the members of a pond community	Chapter 1; Some experiments with earthworms (p. 17)
6. Effects Caused By Freezing (p. 135)	To test the effect of freezing on the members of a pond community	Chapter 1
7. Effects Caused by Drying (p. 135)	To test the effect of drying on the members of a pond community	Chapter 1

RELATED FILMS

	Min.		
World in a Marsh	22	Color	NFBC
The Pond	20	Color	IFB
The Community	11	B&W Color	EBF
The Cave Community	13	B&W Color	EBF
The Desert	22	B&W Color	EBF
The Grasslands	17	B&W Color	EBF
Life in the Forest	11	B&W Color	EBF

OVERVIEW AND RATIONALE

This section is divided into three parts. The first concerns the use of reference books and guides, and certain laboratory procedures. The second part presents a number of demonstrations and experiments related to the chapters in Block I. The chapter and section most closely related to each of these activities is indicated in *The Chapter at a Glance* outline. Part three provides instructions for a detailed study of a pond community. The activities in this third part form a sequential series and can be handled as an individual or small group investigation. If presented after Chapter 5, this study will serve to summarize some of the major ideas of Block I, and at the same time, introduce Block II, which deals with the natural community and interaction among its members. Thus, part three provides a series of laboratory experiences designed to bridge the first two chapter blocks.

MAKING USE OF THE LABORATORY INVESTIGATIONS

You probably will want to present the activities in parts one and two as supplements to the development of Chapters 1 through 5. For example, the sections called *Reference Books and Guides* and *Biological Equipment* might be used in connection with Chapter 1 and particularly with the section entitled *Methods of the Biologist.* Similarly, the sections *Collecting and Culturing* and *Preserving Specimens* might be used with Chapter 1 and the study of *A Pond Environment.* The various exercises in Part II may be employed in connection with study of the chapters to which they are related.

Part three is planned to be used as a unit of laboratory experiences. Each activity in the series is part of a detailed study of a natural community. The activities relate back to material covered in the text, make use of laboratory techniques presented in earlier work, and at the same time set the stage for the next block of text chapters. If possible, this study should be presented without interruption. That is, students should work on the investigation each day for several days so they have a "full-time" field and laboratory experience. In this manner they may gain some feeling for the way biologists work by making use of observation techniques, reference materials, instruments, collecting equipment, classification keys, and controlled experiments.

If you wish to expand this kind of experience, certain additional laboratory activities from other parts of the text may be used here, instead of as supplements to the chapters. These related activities are indicated in *The Chapter at a Glance.*

LABORATORY SUGGESTIONS

Part I, Books and Instruments

Reference Books and Guides (page 105, one period) If your students have had little experience using reference books, you may want to spend some time with them investigating good sources of information. A good way to begin is to use the text book as an example. Discuss the use of the table of contents, the index, and the glossary. You might have them find certain chapters, search for pages concerning various topics, and locate the definitions of selected terms. Also point out the lists of references at the end of each chapter and describe the way this section can be used to discover more information related to the chapter topics.

The Use of Keys, (page 106, one to three periods) See *Getting Started,* Chapter 5, Teacher's Guide, page 39.

Biological Equipment, (page 106) If you have samples of the various instruments and pieces of glassware, you may want to display them for students to observe and handle. A game can be made of naming unlabeled items and explaining their uses. Or these tools might be used as things to classify in connection with *Getting Started,* Chapter 5, page 39. The technique for using each instrument can also be demonstrated when it is appropriate and needed for a laboratory activity.

Collecting and Culturing (page 108) Students often can supply baby food bottles and peanut butter jars from home. These usually have wide mouths and make good containers for collecting and displaying specimens. They also can be used for various experimental purposes. One-gallon mayonnaise or pickle jars are often discarded by school cafeterias and local restaurants. These make very satisfactory and inexpensive aquariums and terrariums.

Be sure to emphasize the importance of conserving resources. Students should be cautioned to collect small samples and to return them to the collection locations, after a study is completed.

The killing jar is particularly useful for killing small insects and crustaceans that are to be preserved. Carbon tetrachloride gives off poisonous vapors and should be handled with great care. Insect nets can be made from nylon mesh sewed to a rim of heavy wire about twelve inches in diameter. The wire can be fastened to a wooden handle three to four feet long.

Nets for scooping up algae or material from a pond bottom should be made of much heavier netting or cloth. A garden rake may be useful in collecting specimens from the bottom of ponds or streams.

Whenever specimens are collected, it is important to prevent crowding in the containers, to leave the container uncapped or with a large air space, and to keep the water and specimens from becoming warm. If all of these instructions are followed, culturing will be easier for your students.

Use of the Microscope (page 112, two to three periods)

Materials: 24 microscopes, 24 slides, 24 cover glasses, lens paper.

When students are using microscopes for the first time, it is a good idea to give them fairly simple objects to view. A hair or a thread mounted dry under a cover glass may be used to start. Or you might expand on *Some Tests of Observation,* Chapter 1, page 15, by having them observe a tiny section of a glossy magazine picture. Use both black and white and color pictures. These can also be mounted dry. Or students may be interested in viewing a bit of frayed tissue paper and a pinch of salt or sugar.

Some idea of the size of microscopic objects can be gained by viewing the millimeter scale on a transparent rule, using both high and low-power lenses. This can be followed by a study of such things as insect wings and legs. Then a sample of any available pond culture might be examined.

See *Getting Started,* Chapter 2, page 11 for other suggestions.

Temporary Microscope Mounts (page 114) Eosin stain can be prepared by dissolving 0.5 grams of eosin powder in 100 ml of distilled water. Gentian violet stain is a solution of 0.5 gm of powdered gentian violet in 100 ml of distilled water. Prepared solutions are available from biological supply houses.

Part II, Demonstrations and Experiments

Physical Factors of the Environment (page 115, one period to set up)

Materials: bean seeds, 12 planters, soil, water, 12 millimeter rules.

This is a simple experiment that will clearly demonstrate the effect of a physical, environmental factor. It is best to soak the seeds in water overnight before planting them. This will speed up the sprouting process. If bean seeds are not available, other kinds can be substituted. The plants growing in the dark probably will fail to become green, as light is necessary for chlorophyll production. They also may grow taller than those in the light. Those grown in direct light or in dim light probably will turn green as they sprout. Also, they will bend toward the light source, if it comes from the side.

Students can keep track of growth by measuring the height of several plants (to the nearest millimeter) in each planter every day and calculating the averages. Capable students may want to plot these data on graph paper. Height in millimeters can be used as units for the vertical axis, and time in days as units for the horizontal axis. The data for different planters can be plotted in various colors.

ANALYSIS QUESTIONS (page 116)

1. The plants in direct sunlight probably grew best.
2. The plants in darkness probably grew rapidly at first, but failed to turn green. In time, these plants die, because they are unable to make foods.
3. Sunlight is necessary for the production of the green pigment, chlorophyll, and is important to normal growth.

High Temperature and Life (page 116, one period)

Materials: 24 microscopes, 24 slides, on 24 cover glasses, pond culture, 24 test tubes, 6 Bunsen burners, 24 test tube holders.

Students should be advised on how to boil liquid in a test tube. Pyrex or other heat-resistant tubes should be used. The tube is held about an inch and one-half from the top with the holder. The burner should be adjusted so that it is burning with a nonluminous flame. The bottom of the tube is passed slowly in and out of the flame until the liquid boils. It should be tilted and pointed away from the students, so that if it boils over rapidly, it will not burn anyone.

The culture should be examined microscopically before and after heating. Students will note that the living things are destroyed or killed. Their appearance may be changed, and they will show loss of movement after boiling.

ANALYSIS QUESTIONS (page 116)

1. There is no evidence that small animals survived the heating. Formerly active forms become inactive after boiling.
2. High temperature or boiling destroys simple animals.
3. The effect of high temperature on algae could be determined in a similar manner. However, it may be more difficult to demonstrate that the algae were killed, as they do not move about. Heated algae could be observed each day for several days to see if they continued growing. An unheated sample may be used as a control.
4. A sample could be frozen and later thawed. An unfrozen sample should be kept as a control.

A Chemical Change that Releases Carbon (page 116, one-third period)

Materials: corn oil, heavy cord, 24 test tubes, 24 test tube holders.

This demonstration might be performed by two students for the benefit of the others. It illustrates that a fat (corn oil) contains energy which is released by oxidation. It also demonstrates that the fat contains the element carbon which is released when oxidation is incomplete.

ANALYSIS QUESTIONS (page 117)

1. Carbon, hydrogen, and oxygen are found in fats. The same elements occur in carbohydrates.
2. A chemical change took place when the oil burned. The fact that new substances (carbon and smoke) were formed is evidence of such a change.
3. Some of the carbon combined with oxygen by oxidation and became carbon dioxide gas. This gas escaped into the air. The burned remnant of the cord also contains carbon.
4. The hydrogen and oxygen escaped as water vapor.

How You Can Detect Radioactivity (page 117, one period)

Materials: 1 Geiger counter, 1 radium dial watch.

This demonstration might be conducted by two or three capable students for the benefit of the class. After the counter is operating, determine the average ground rate in counts per minute. Then place the radium dial watch a short distance from the probe and determine the new rate. The difference between the ground and the new rate is due to the radium of the watch dial.

By moving the watch closer or farther away, you can demonstrate that the rate varies with the distance. The number of counts recorded will be inversely proportional to the square of the distance. Thus, if the count is 100 at one inch, it will be about one-fourth this (25) at two inches, and one-ninth at three inches. You also can demonstrate that a thin piece of metal between the watch and the probe will result in a great reduction in the counts recorded. This is due to absorption of radiation by the metal. The thicker the metal, the greater the absorption.

Other radioactive substances may be located in the classroom or at home. Check any compounds of potassium available. They will contain a naturally occurring radioactive isotope of potassium. Check a sample of ash from a fireplace and any old pottery dishes that are orange. Such things sometimes contain radioactive materials.

ANALYSIS QUESTIONS (page 118)

1. Radioactive substances occur in soil everywhere and are taken in by plants. Thus it is expected that some will enter our bodies in food as well as in drink.
2. Nine units.

An Osmosis Demonstration (page 119, one period)

Materials: semipermeable membrane, 24 thistle tube, sugar solution, 24 rubber bands, 24 battery jars.

For a semipermeable membrane, you can use such things as uncoated cellophane, goldbeater's membrane, or pig bladder. These are available from biological supply houses.

It is very important that the rubber bands hold the membrane tightly against the thistle tube. If there are any leaks, the demonstration is not likely to succeed. Also be sure that the membrane has no visible holes in it.

Students should be able to note a rise in the level of the sugar solution within a class period. If there is no significant movement in that time, check the membrane for leaks, and leave the apparatus set up overnight.

ANALYSIS QUESTIONS (page 119)

1. The glucose solution rose as osmotic pressure developed within the thistle tube. This pressure was due to water moving into the tube through the semipermeable membrane. Water was more concentrated outside the tube than inside, and it tended to move from where it was more concentrated to where it was less concentrated.

2. Water molecules were passing from the battery jar into the thistle tube. The increased volume in the tube is evidence of this.
3. It is not possible to tell by looking if glucose molecules were passing into the battery jar. However, if glucose was used, students may want to test the water for sugar, before and after the demonstration. Fehling's or Benedict's solutions can be used for this purpose. See Chapter 1, page 33 for instructions.
4. The action is expected to continue until the pressures on either side of the membrane are equalized.

Osmosis in a Carrot (120, one period)

Materials: carrot, glucose solution, 6 corkborers, 24 one-hole stoppers, 24 glass tubes, string, 24 battery jars.

This might be set up for the class by a small committee. Have them use a corkborer about the size of the one-hole stopper, so that a tight fit will be possible. A rubber stopper is less likely to leak than a cork. The string is tied around the outside to help prevent leaks. The same sugar solution as that used in the previous demonstration can be employed.

It is unlikely that students will be able to note movement in the tube before the end of a class period. Have them mark the liquid level and check it again the next day.

ANALYSIS QUESTIONS (page 120)

1. The glucose solution rose, because water entered the tube by passing through the semipermeable membranes of the carrot cells. This increased the volume of liquid in the tube.
2. The presence of glucose molecules in the battery jar could be determined using Fehling's or Benedict's solutions. The test should be performed before and after the demonstration. A second battery jar containing a second carrot without sugar would serve as a control for this test.
3. There must have been many membranes involved as there are many carrot cells in the wall of the carrot.

Behavior of Paramecium (page 121, one period)

Materials: paramecium culture, eosin, 24 microscopes, 24 slides, 24 dissection needles.

See laboratory suggestions, Chapter 3 of this manual page 21 for a discussion of paramecium.

ANALYSIS QUESTIONS (page 121)

1. The paramecia tend to move away from the eosin in the water. This avoiding reaction, however, is doomed to failure as the eosin spreads progressively through the culture drop.
2. When a paramecium has absorbed too much eosin, it is killed. Students can easily observe the slowing down of its reactions. In the end, it becomes immobile.
3. The same thing happens, since the iodine also is toxic to paramecium. Iodine solution, however, cannot be seen as readily as eosin while it diffuses through the culture drop.

Fission in Paramecium (page 121, one period)

Materials: 24 prepared slides of dividing paramecia, 24 microscopes.

Students are more likely to see paramecium in various stages of fission and conjugation if prepared slides are used. These are available from biological supply houses. The organisms will be stained and are relatively large and easy to study. If you have an active culture of protozoans, students may want to see if they can locate single cells dividing.

ANALYSIS QUESTIONS (page 121)

1. Paramecium does not divide until it has grown to a certain size.
2. The two new cells are smaller than the

parent cell. Otherwise they are very much like the parent.

3. Conjugation results in the exchange of nuclear material between two cells. This tends to stimulate the organisms to resume growth and reproduction for a number of generations.

Testing for Starch in Green Leaves (page 122, one and one-half periods)

Materials: 6 geranium plants, 12 opaque bags, alcohol, 12 beakers, water, 12 Bunsen burners, 6 pans for water bath, 12 ring stands, iodine solution, 12 medicine droppers, 12 petri dishes.

If geranium plants are not available, try some other soft-leaf plant such as coleus or mallow. An opaque bag can be constructed by folding black construction paper to fit the leaf. The important thing is that no light reaches the leaf while it is covered. Keep the plant in bright sunlight.

Drop the leaves to be tested in boiling water to soften the cell walls. Then transfer them to the hot alcohol. Alcohol gives off flammable vapor and care must be taken to prevent fire. A hot plate can be used to heat the alcohol safely or heat it in a water bath, as described in the text book. In any event, keep open flames away from the hot alcohol.

The leaves will lose their green color in the alcohol and will appear white or yellowish. However, a given quantity of alcohol will only absorb so much chlorophyll. If the leaves do not become white, pour off the green alcohol and add new alcohol. Have students cover the leaves with iodine solution in a petri dish or on a paper towel. It is expected that the leaf from the light will turn blue-black revealing the presence of starch, while the covered leaf remains unchanged or darkens only slightly.

ANALYSIS QUESTIONS (page 123)

1. The leaf from the sunlight had the greater amount of starch.
2. The starch was transported away or used by the cells of the covered leaf. Meanwhile no new starch was produced.
3. Answers will vary. The experiment could be repeated using artificial light rather than sunlight. The results should be the same.

Collecting Oxygen Under Water (page 123, one-third period to set up)

Materials: Elodea, 1 battery jar, 1 test tube, water.

This demonstration can be set up for the class by two or three students. If *Elodea* is not available, a mass of green algae can be substituted. You can increase the rate at which the gas is collected by placing several pieces of plant under a funnel, the stem of which is in the collecting tube. Also, if the apparatus is left in bright artificial light for a number of hours, the rate of gas production should increase.

Some of the gas collected will be air that was dissolved in the water. However, students should be able to see bubbles coming from the plant stems and these will contain oxygen.

ANALYSIS QUESTIONS (page 124)

1. The released oxygen comes from water molecules.
2. In the dark, oxygen bubbles would not rise from the plant because the light phase of photosynthesis could not take place. Evidence of this could be gathered by placing in the dark an apparatus similar to that used in the demonstrations.

Separating Plant Pigments (page 124, one period)

Materials: Beet leaves, deep pan for water bath, ring stand, 2 beakers, alcohol, Bunsen burners, 2 test tubes, stirring rod, graduates, petroleum ether.

This demonstration can be performed for the class by two or three students. If beet leaves are not available, you might try some from coleus or spinach. Open flames should not be used near the alcohol or petroleum ether, as both produce flammable vapors. Heat the beaker of alcohol by placing it on a hot plate or in a water bath as described in the text book.

ANALYSIS QUESTIONS (page 124)

1. The upper layer is green and thus contains the chlorophyll. The lower layer is yellow.
2. Answers will vary. Red leaves could be tested for the presence of chlorophyll by extracting the plant pigments with alcohol and separating them as in the demonstration.

Special Spore Cells (page 125, one period)

Materials: 24 prepared slides of *Spirogyra* conjugating, 24 microscopes.

Students should have no difficulty observing the structures described in the instructions.

ANALYSIS QUESTIONS (page 125)

1. The cell that *receives* the contents of the other cell paired with it is the female.
2. The spore cell has a heavier wall and contains an oval mass of material rather than a spiral chloroplast.
3. This type of "spore cell" has a heavy cell wall surrounding the zygote. The zygote is more resistant to changes in the environment than an ordinary cell and remains in a resting state until the following spring when it may germinate.

Observation of Bread Mold (page 126, one-half period to set up)

Materials: paper towels, 24 petri dishes, stale bread, 24 hand lenses.

The bread can be exposed to mold spores by brushing dust particles on it or by letting it stand in the air for an hour or so. It is important to keep the bread moist, but not so wet that it becomes soft. Also, it should be kept in the dark at room temperature or slightly higher. A drawer near a heater should work well for this purpose.

Students should have no difficulty locating the parts described in the directions.

ANALYSIS QUESTIONS (page 126)

1. The spores probably got on the bread when it was exposed to the dust or air.
2. The rhizoids are rootlike parts, through which food and moisture are absorbed from the bread.
3. Division of labor occurs among the hyphae, in that some give rise to food and water absorbing parts, while others function in reproduction by forming spores. Still others form connections between the various parts of the mold body.

Reproduction of Yeast Cells (page 126, one period)

Materials: yeast cell culture, 24 microscopes, 24 slides, 24 cover glasses.

A yeast cell culture can be prepared by adding half a package of active dry yeast to 500 milliliters of a 10% solution of molasses or grape juice in water. Keep this culture in a warm place for about twenty-four hours.

Yeast cells are seen most easily under high-power in dim light. A drop of neutral red stain added to the preparation will make the cells more visible. Neutral red is prepared by dissolving 1 gram of stain in 100 milliliters of distilled water. This stain will not kill the cells, but will stain certain parts and granules within them. Also, dead cells will stain more completely than living ones.

ANALYSIS QUESTIONS (page 127)

1. Paramecium divides into two relatively equal parts, while yeast cells reproduce by forming tiny buds that grow out from the side of the parent cell.

2. Yeast cells must obtain "ready-made" food from the environment.
3. Yeast cells can grow and reproduce in the dark, if the environment is favorable. They must be supplied with water, a food supply, and a suitable temperature.

Behavior of an Earthworm (page 127, one period)

Materials: 12 earthworms, 12 hand lenses, soil, paper towel, 12 tooth picks, 6 flashlights.

See *Some Experiments With Earthworms,* Chapter 1, of this manual, page 17.

Earthworms generally try to avoid light and will contract when touched. Students may want to test other kinds of responses, and should be encouraged to do so. However, you should insist that they check with you before beginning an investigation. They might see if there is any response to the weak acid in vinegar. Try administering a little with a cotton swab. They can test the response to position by placing a worm upside down on a moist paper towel. Or they may want to see if a worm can crawl through a short length of glass tubing.

ANALYSIS QUESTIONS (page 128)

1. The bristles serve as anchors when the worm crawls through the soil.
2. Earthworms are sensitive to their environment. They avoid light and usually contract when touched by moving objects.
3. Earthworms obtain oxygen from the air. The gas diffuses through their moist body surfaces and is carried to body parts by the blood.

Dissecting an Earthworm (page 128, one period)

Materials: 24 preserved earthworms, 24 dissecting trays, 24 scalpels, 24 scissors, 24 forceps, 24 dissecting needles, 144 pins.

Preserved earthworms, a foot or more in length, can be purchased from biological supply houses. If paraffin lined dissecting trays are not available, use a piece of cork board or heavy cardboard. A single-edged razor blade will substitute for a scalpel. Heavy sewing needles can be used as dissecting needles. Some students may indicate a reluctance to begin a dissection. Others usually are eager to get started. If this happens, have them work in small groups of two or three students. Some can do the dissecting and the others can watch. As a rule, most of them will be working with specimens by the end of the period.

ANALYSIS QUESTIONS (page 129)

1. Oxygen and digested food are carried to the body cells by the earthworm's blood. Wastes are removed from body cells by the blood stream. Wastes that form in the body cavity pass out through special excretory organs.
2. An earthworm's actions are controlled by a nerve chain, lying along the lower side of the body cavity. Although there is a thickening at the head end of this nerve chain that makes up a sort of "brain," earthworms do not "think." Instead, they respond to changes in their environments by reflex-type actions.

A Culture of Bacteria (page 129, one period)

Materials: 24 water jars, dried beans, 24 medicine droppers, 24 microscopes, 24 slides, 24 cover glasses, 24 toothpicks, 6 Bunsen burners, methylene blue stain.

The decay bacteria that appears in the bean water often produce unpleasant odors. These odors can be controlled, somewhat, by placing a mass of cotton in the mouth of the jar or by covering the jar with a bit of plastic film. Also, caution the students to remove very small samples for viewing. Bacteria are quite small, and microscopes with high-power objective lenses (40X) will be necessary for this study.

Other decay bacteria can be cultured by allowing leaves, grass, or hay to stand in water for several days. Another method makes use of peppercorns, which are left in water for a time.

Methylene blue stain is prepared by dissolving 0.3 grams of the powdered stain in 30 milliliters of ethyl alcohol and adding 100 milliliters of distilled water.

ANALYSIS QUESTIONS (page 129)

1. The bacteria may have been on the bean seeds, or in the water. Also, they may have come from the air as spores on dust particles. The source could be investigated by setting up other jars of bean water, but sterilizing various parts first.
2. Answers will vary.
3. Bacteria do not have organized nuclei.

Bacteria, Molds, and Decay (page 130, one-half period to set up)

Materials: ripe fruit, crushed grapes, flower stems, cottage cheese, cornstarch, water, 24 containers, 24 hand lenses, 24 microscopes, 24 slides, 24 cover glasses.

Students working in small groups can set up a variety of conditions. Have them use widemouth jars such as peanut butter jars. Keep the samples at room temperature in the dark or in very dim light. A number of kinds of growth should appear in a few days. Students can study molds with hand lenses. They also can prepare wet mount slides for viewing with a low power microscope. They may find yeasts and bacteria in the liquid from some of the jars. Have them prepare slides as described on page 114.

ANALYSIS QUESTIONS (page 130)

1. Answers will vary.
2. Answers will vary.
3. As the organisms grew, the plant and animal materials became changed in form. They decayed. Some of them gave off unpleasant odors.
4. Foods decay as a result of microorganism activity. Molds and bacteria break down the food and use it as an energy source.

LABORATORY SUGGESTIONS

Part III, Study of a Pond Community

This study is planned to interrelate the materials of Blocks I and II, and can be presented as a series of sequential laboratory and field experiences. The study will require two to four weeks time, depending on how it is handled. Each student may want to carry on an individual study or small groups of students may want to specialize in one phase of the study, such as mapping, collecting and preserving specimens, or investigating interrelationships among organisms. In any event, it is desirable to make this presentation a full-time laboratory and field experience lasting a number of days and employing a variety of techniques.

Selecting a Community for Investigation (page 131)

Materials: 24 thermometers, 24 meter sticks.

Although the instructions concern a pond community they can be modified to fit almost any situation. For example, a similar study can be made in a forest, a grassland, or a desert. A backyard, a vacant lot, or a portion of the school grounds also can serve as a study area.

If individual investigations are made, it is important to limit the size of the area concerned. Groups, of course, can work with larger sections.

Populations of the Community (page 132)

Materials: Equipment for collecting, culturing, and preserving specimens (see page 108, *Collecting and Culturing* and page 111, *Preserving Specimens*), classification guides, 24 microscopes, 24 slides, 24 cover glasses.

In order to determine the presence of certain large organisms in an area, it may be wise to have only a few students make the initial observations. They should station themselves quietly in inconspicuous places and make notes concerning the kinds, numbers, and activities of birds, mammals, and other large forms seen. Later, larger groups may make detailed observations of living things that are less likely to be disturbed by human presence.

Be sure to emphasize the importance of collecting small samples and returning those forms not needed for a permanent collection. Find out the special types of plant and animal life that are protected by local laws and regulations, and inform the students accordingly.

The Roles of Community Members (page 133)

Students should find out as much as they can by direct observation of individual organisms. The study should include field observations, as well as observations made on specimens cultured in the laboratory. Then reference books can be consulted to verify observations and gather additional information about habits and relationships.

ANALYSIS QUESTIONS (page 133)

1. Answers will vary. Numbers and kinds of organisms present in a community are expected to change with the season.
2. The interrelationships within a natural community are such that the removal of any population will be reflected in other populations. For example, effects will be noted in those populations that are fed upon by the missing species, and those that feed on it.
3. Members of nearby communities often interact. For example, large animals may move from one area to another, feeding on plants and other animals. Trees of a forest may shade the organisms in a grassland nearby.
4. Bacteria and fungi act to produce decay of dead organisms in the freshwater community, and in turn, serve as food for various larger forms.

Interaction Between Community Members and the Environment (page 134)

Materials: samples of pond water, 24 microscopes, 24 slides, 24 cover glasses, 24 jars.

This investigation can be set up early in the study and checked every few days, both grossly and microscopically. Students should be able to predict a change in the culture kept in the dark, due to the death of the green plants which serve as food producers. Other changes will be noted in the numbers and kinds of organisms present in each sample.

ANALYSIS QUESTIONS (page 134)

1. Green plants die when left in the dark.
2. Since the animals depend on the green plants for food, their numbers decrease as the plants die.
3. Answers will vary.
4. The effect of colored light can be tested by wrapping jars with samples of pond cultures in colored cellophane. A jar wrapped in uncolored cellophane can serve as a control.

Effects of Temperature Change (page 134)

Materials: samples of pond cultures, 24 microscopes, 24 slides, 24 cover glasses, refrigerator.

Emphasize the problem of testing the effect of temperature alone. Although the refrigerator provides a lowered temperature, it also prevents light from reaching the sample. Thus, at least two factors vary, temperature and light. The control should be like the test, except for the single factor being tested. For this reason, it is suggested that the control be kept at room temperature, but in the dark.

It is expected that both samples will change, as in the previous study, due to the absence of light. However, the refrigerator sample will change more slowly, because lowered temperatures result in slower chemical reactions.

ANALYSIS QUESTIONS (page 135)

1. Green plants in the dark at refrigerator temperature change more slowly than those in the dark at room temperature.
2. The animals move more slowly at low temperature. Also, their numbers change more slowly in the refrigerator than at room temperature.
3. Answers will vary.

Effects Caused by Freezing (page 135)

Materials: pond water samples, 24 plastic containers or 24 test tubes with cotton plugs, refrigerator, 24 microscopes, 24 slides, 24 cover glasses.

Students will find that the protozoans are nearly all destroyed by freezing. The cells of many will be broken, so that they are difficult to recognize after thawing. Some of the algae may appear unchanged.

Students may want to keep frozen samples for some time to see if the protozoans reappear and if the algae continue to grow. If so, it will be important to prevent untreated forms from entering the samples. To do this, freeze one-inch samples in cotton plugged test tubes, and leave the tubes plugged for a number of days after thawing. Then check the samples microscopically. Any forms present must have survived the freezing.

ANALYSIS QUESTIONS (page 135)

1. Freezing seems to destroy many of the simple organisms.
2. Cell structure and movement were aids in deciding if something was alive or not. Growth and change in numbers due to reproduction is another evidence of survival.

Effects Caused by Drying (page 135)

Materials: pond water samples, 24 widemouth jars, 24 microscopes, 24 slides, 24 cover glasses.

Students may want to find out what forms will reappear in the dried samples when water is added. To do this, have them add an amount of distilled water equal to the amount in the original sample. A similar thing happens when rain water fills a dry pond or lake.

ANALYSIS QUESTIONS (page 136)

1. As the water evaporates, the organisms become more and more concentrated and begin to disappear.
2. Organisms which survive drying must be able to form coverings that resist evaporation of cell water. Eggs and spores survive in some cases.
3. To see if bacteria survive drying, you might sterilize cotton-plugged tubes containing water and a bean seed. Then a bit of material from some dried out pond culture could be added to the tube. If the bean decayed, this would be evidence that bacteria were present.

WORD MEANINGS (page 138)

1. A solution that is commonly used to preserve the parts of plants and animals is *(c) formalin.*
2. When water molecules pass through a semipermeable membrane, it is a case of *(b) osmosis.*
3. In the following list, the substance you would use to stain a cell red is *(a) eosin.*
4. When a yeast cell divides; the process is known as *(d) budding.*
5. If you found a group of bullfrogs living in and about a pond you could describe the group as a *(c) population.*
6. A group of animals of various types living together near the bottom of a deep trench in the ocean could be described as a *(d) community.*

SELF TEST (pages 139-140)

1. True
2. True
3. False. Carbon is found in carbohydrates, fats, and proteins.
4. False. Radioactivity occurs naturally in such elements as radium and uranium.

5. False. Water molecules pass through a semipermeable membrane faster than sugar molecules.
6. True
7. False. Paramecium may divide to form two cells without conjugating.
8. True
9. True
10. True
11. False. Green leaves often contain pigments in addition to chlorophyll.
12. False. Yeast cells, like many other cells have nuclei.
13. False. Earthworms obtain oxygen from air by absorbing it into the blood near their body surfaces.
14. True
15. False. Bacteria are likely to be found in every pond culture.
16. True
17. False. Sunlight is necessary for the life of food producers in a pond community.
18. False. Some living things can survive freezing.
19. False. Some living things can survive drying.
20. True

DISCUSSION QUESTIONS (page 140)

1. The test demonstrated that the larger forms of life present were killed. It did not demonstrate that miscroscopic forms such as bacteria were affected. From such limited evidence, one should not conclude that 212°F. will kill all living things.
2. Water changing to ice is an example of a physical change for no new substance is produced. Water and ice are composed of the same compound, H_2O.
3. Radioactive materials are found in the earth's surface, in the materials of our buildings, and in the bodies of plants and animals. Therefore, it would be strange if a Geiger counter showed no radioactivity in the environment.
4. Although both large and small molecules may pass through the same membrane, the smaller, more rapidly moving molecules are likely to pass through more frequently.
5. Osmosis is the process by which water passes through cell membranes, and therefore must be considered as part of normal cell activity.
6. Bacteria and fungi are closely associated with decay processes. Without decay, the dead bodies of plants and animals would cover the earth's surface, vital chemicals would be trapped in these bodies, and in time, life as we know it might cease to exist.
7. Algae represent the basic food producers of a pond community, upon which small animals depend for an energy source.
8. Algae would be more common in a pond than turtles or insects, because all animals depend on plants for food and are thus limited by the amount of plant material present.
9. If conditions are changing, you can expect corresponding changes in the populations of organisms living in an area. The plants and animals adapted to living in water are usually different from those adapted to living on mud flats.
10. You could predict that the green plants would die in a pond receiving no light. After the plants were gone, the animals would be without a food source and, in turn, would die.
11. Some forms of life must be able to survive freezing and then reappear when the waters thaw. Some species continue to live beneath the ice. Various new individuals arise from eggs, seeds, and spores that survive during the winter period.
12. If conditions are favorable in a sealed jar, the community should be able to continue for a period of time. In such a situation, the plants would supply food and oxygen which animals can use. In turn, the animals supply carbon dioxide and other chemical wastes needed by plants.
13. Such factors as sunlight, temperature, pressure, available water, and type of

soil are related to the kind of community that exists in a given area.

14. It is expected that the number and kinds of organisms in a pond community will vary as the conditions vary. Thus, you would expect a greater number of frogs in the summer following the breeding season than in early spring when they first come out of hibernation.

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BLOCK II The Natural Community

CHAPTER 6 Food Resources

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	To survive, organisms must obtain food and avoid being eaten. Animals are consumers, rather than foodmakers. Competition for food varies as the food supply varies.	Aquariums and Terrariums (p. 234)
2. Community Food Supplies	Communities vary in size.	
A. Communities large and small	Forests, grassland, coastal bays, and mountain valleys contain communities. Some populations occur in a number of different communities.	Things To Do, # 1, 2 (p. 159)
B. Natural barriers	Other populations are restricted to certain conditions by natural barriers, such as temperature, moisture, soil chemicals, or pressure.	
C. Food as a factor	When conditions are favorable for food production, a large animal population can be supported. Algae are basic food producers in aquatic communities. Seed plants are the basic food producers on land.	Things To Do, #3, 4 (p. 159)
3. Variation in Food Supplies	As conditions change, the food supply changes also.	
A. The last ice age	Food supplies vary from year to year and from century to century.	Things To Do, #5, 6 (p. 159)
B. The effect of seasons	Plant populations expand in the spring. This is followed by an expansion of animal populations. In the fall, both plant and animal populations decrease.	
4. Food Makers of Land Areas	Roots, stems, and leaves function in foodmaking and	Types of Higher Plants (p. 261)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	transport of materials within the plant.	
A. Roots of seed plants	Roots anchor plants and absorb water and dissolved minerals through root hairs. Some roots store food.	Observing Root Hairs (p. 151)
B. Stems of seed plants	Stems hold the leaves up into the sunlight and serve as pathways connecting roots and leaves. Some stems store food and water.	Things To Do, #7 (p. 160) Stem Types (p. 153)
Structures of plant stems	Stems contain growing tissue and two types of ducts; phloem ducts conduct food, while xylem ducts conduct water. The growth rings in woody stems are made up of old xylem tissue.	
C. Leaves of seed plants	Leaves are the primary foodmaking centers. Leaf parts are adapted to transport water and food, exchange gases with air, and carry on photosynthesis.	Leaf Types and Structures (p. 155) Carbon Dioxide and Photosynthesis (p. 156) Things To Do, #8 (p. 160) Rate of Photosynthesis (p. 258) Loss of Water by Plants (p. 260)
5. Plants, Animals, and Oxygen		
A. Plant cells and animal cells	Although green plant cells release oxygen as a byproduct of photosynthesis, plant cells, as well as animal cells, use oxygen in the process of obtaining energy from stored food.	

RELATED FILMS

	Min.		
Colour of Life	24	Color	NFBC
Roots of Plants	11	B&W Color	EBF
Photosynthesis	21	Color	EBF
Role of Green Plants	28	Color	McGraw
Leaves	28	Color	McGraw
Stems	28	Color	McGraw

OVERVIEW AND RATIONALE

The chapters of Block II concern the natural community and interrelationships among its members and their environment. Earlier, it was pointed out that every living thing requires food as a source of energy and needs raw materials. Chapter 6 expands on this idea and presents more details relating to the food resources of natural communities.

The chapter begins with a discussion of how communities vary with the physical conditions. Animal populations are seen as being dependent upon plant populations. Their numbers increase or decrease as the plant numbers vary from season to season and century to century.

Algae, the basic source of food in aquatic communities, were investigated in Block I. Now, the seed plants are described as the primary foodmakers for land communities. Roots, stems, and leaves are presented as plant organs involved in photosynthesis and the transport of materials within the plant body. The role of each of these organs is discussed together with a description of its major tissues and their functions.

The chapter ends with a brief discussion of the use of oxygen in plant and animal cells.

GETTING STARTED

As Chapter 6 introduces the study of interrelationships within natural communities, it might be well to have students establish some sample communities in the classroom. You may want to have the students consider the problems involved with establishing a "balanced aquarium." This is an aquarium containing both plants and animals, which will continue living even though the aquarium is sealed up.

Ask students to describe the things and conditions needed in a sealed community. They should suggest green plants, a limited number of animals, and some microorganisms. They should also mention water, light, air, minerals, and a suitable temperature. Have them consider the problem of balancing the amounts of plants, animals, and microorganisms, and determining the proper types of minerals to be included.

Some students may want to try setting up such an aquarium in miniature. They can try putting various combinations of things in small jars with screw caps, or test tubes sealed with rubber stoppers. Students should be cautioned to include only one or two very small animals. They might try a snail or small fish at the start. Pond water can be used to supply microorganisms and minerals.

Records should be kept. They should indicate what was included in each tube, together with observations made from time to time.

Students may also be interested in discussing the problems facing the designers of space crafts planned to maintain human life in a "sealed container" for a long period of time.

Individuals or small groups of students may want to set up other kinds of sample communities. In *Part I* of the Laboratory Investigations for Block II, p. 254, there are directions for establishing a freshwater aquarium, a bog terrarium, a woodland terrarium, and a desert terrarium. Each of these can serve as an interesting display and a useful example of interrelationships that will be discussed in the chapters of Block II.

If living specimens cannot be obtained, students can construct representations from paper or clay. Or they may display models of animals among artificial plants arranged to illustrate various natural communities.

CHAPTER NOTES

Community Food Supplies (page 144) Emphasize that a community is made up of a group of populations living together. Ask students to identify types of communities that occur in local areas. Also have them describe some of the members of each local community. Students should be able to identify foodmakers and consumers found in each association.

Consumers sometimes are labeled by their position in food chains. Animals that eat plants directly are called "first order consumers." Animals that feed on the plant-eaters are called "second order consumers," and so forth. Students may want to identify their own position in various food chains. For example, when they eat vegetables, they are acting as first order consumers. If they eat steak, they are second order consumers. Ask students to describe food chains in which man is a third or fourth order consumer.

When you discuss local plant and animal communities, you might want to ask students to describe natural barriers that seem to limit these communities to certain areas.

Variation in Food Supplies (page 148) Emphasize how consumers are affected by physical factors and biological factors that act on the foodmakers. Ask students to describe conditions that they know about in which consumer populations have greatly increased or decreased. Ask them also to identify the factors that have affected the foodmakers in each case. They may mention examples involving crop destruction by insects, droughts, land erosion, floods, dust storms, or diseases.

Plants, Animals, and Oxygen (page 156) Ask students to pay particular attention to this section. It is likely that they will understand that plants use carbon dioxide and release oxygen during photosynthesis, and that animals release carbon dioxide and use oxygen in respiration. However, students sometimes miss the idea that plants, like animals, use oxygen when they release the energy stored in food made by photosynthesis.

LABORATORY SUGGESTIONS

Observing Root Hairs (page 151, one period)

This is a simple demonstration of root hair structure, and students should have no difficulty with it.

Materials: 24 microscopes, 24 slides, 24 cover glasses, 24 fine pointed scissors, cotton, shallow pan, radish seeds.

Be sure to use absorbent cotton, though you may substitute blotting paper. Several thicknesses of moist paper towel will also be satisfactory. Radish seeds sprout within a day or so at room temperature. Other seeds, such as corn or wheat can be used if radish seeds are not available. Or, if you have plants such as sweet potatoes, growing in water, you may be able to find root hairs already formed on the ends of the roots.

Have students notice that each root hair is an extension of a single root cell.

ANALYSIS QUESTIONS (page 151)

1. The root hairs are most numerous a short distance from the tip of the root.
2. The membrane surrounding the root hair is a cell membrane, and it functions to select those materials that will enter the plant, including water and soil minerals.
3. As root hairs represent a group of similar cells performing a specialized function, they would be considered to be a tissue.

Stem Types (page 153, one period)

In this exercise, students will be able to see how the vascular tissues are arranged in two different kinds of stems.

Materials: 24 microscopes, 24 slides, 24 cover glasses, stems of corn and bean plants, 24 razor blades.

Very thin sections can be cut from a soft stem using a single-edged razor blade. Students, of course, must be cautioned in the use of such a sharp instrument. The section should be mounted on a microscope slide in a drop of water, and covered with a cover glass. Then it can be viewed with the low power of a microscope. Prepared slides of such stem cross sections are also available from biological supply houses.

Corn is an example of a monocot plant. This group of plants has vascular tissues in bundles that are scattered irregularly throughout the stem. If corn is not available, a young asparagus stem might be substituted. Bean, sunflower, and maple stems represent dicot plants. This group has vascular bundles arranged in a definite pattern, forming a band, near the outer part of the stem. Each bundle contains xylem and phloem tissue separated by a layer of cambium.

ANALYSIS QUESTIONS (page 153)

The corn stem had scattered ducts as shown in Fig. 6-14A, while the bean stem had an orderly arrangement of ducts like that shown in Fig. 6-14*B*. The celery stem was like the bean stem.

2. The xylem tissue, which is found on the side of the cambium closest to the center of the stem, conducts water from the roots to the leaves. The phloem tissue, on the outside of the cambium layer, conducts food from the leaves to the roots.
3. The vascular bundles in the monocot plants, such as corn, usually lack a cambium layer and therefore do not grow in thickness, once they have reached maturity.

Leaf Types and Structures (page 155)

This activity is in two parts. The first part concerns comparing the structure of leaves from different environments. Part two involves observing stomata on the surface of leaves and calculating their density.

Comparing the Structure of Leaves (page 155, one period)

Materials: 24 hand lenses, 24 millimeter rules, a variety of leaves.

Students may want to organize their observations in the form of a chart, such as the one at the bottom of the page.

If leaves from different kinds of environments are available, have the students note ways in which leaves are adapted to special conditions. Plants from dry areas often have thick succulent leaves, small dry leaves covered with hairlike material, or they may lack leaves altogether, as in the case of many cacti.

Leaves from moist places are less likely to have a waxy covering on the top surface than those from dry environments. The leaves of many aquatic plants, like *Elodea,* dry up rapidly when exposed to air.

Two distinct vein patterns probably will be noted. Monocts like corn, iris, and lilies, generally have veins that run parallel from the base of the leaf to its tip. Dicots like roses, holly, and maple leaves have veins that form a network throughout the leaf blade. Within the dicot group, some leaves have a single main vein or midrib, while others have several main veins running from the base out to the edge of the leaf. Hand lenses will be helpful in the study of vein patterns.

ANALYSIS QUESTIONS (page 155)

1. Leaves generally are green, flattened, and thin. They commonly are longer than they are wide, and they have veins running from the base to the outer edge or tip. Some are attached to the plant by stemlike parts. Many leaves have an upper surface that is smoother than the lower surface.
2. Leaves differ in color, size, shape, thickness, surface texture, and vein pattern.
3. The flat, thin shape of leaves makes it possible for light to reach each cell.
4. Some plants have a hard waxy coat on the upper surface of their leaves. This suggests that carbon dioxide does not enter this side. The under surface of

Kind of Leaf	Type of Environment	Size	Shape	Surface	Color	Vein	Pattern

such leaves generally is softer. Gas would be more likely to enter through this tissue.

Observing the Stomata of Green Leaves (page 155, one period)

Materials: 24 microscopes, 24 slides, 24 cover glasses, 24 forceps, a variety of green leaves.

Almost any kind of leaf will provide suitable material for this observation. However, the leaves should be freshly picked so that they are not wilted. Young leaves generally are easier to work with than older ones. If the leaf does not tear correctly, it may be possible to remove a bit of surface tissue by cutting a tiny nick in the leaf and pulling it away with forceps. In any event, the student needs a section of nearly transparent tissue to mount and observe.

Probably the leaves will vary greatly in the density of stomata. In some cases the stomata may be too numerous to count using low power. In this case, have the students make counts using high power.

Capable students may be interested in calculating the number of stomata in a square centimeter or a square meter of leaf surface. To do this, they will need to know the diameter of the field of view of the microscope. This can be determined by viewing the millimeter scale of a transparent plastic rule. Then the area of the field of view can be calculated, as well as the number of stomata in any larger area.

If plants from different environments are available, have students compare the number of stomata per low-power field for each specimen.

ANALYSIS QUESTIONS (page 155)

1. The guard cells surround the stoma and regulate its size. Guard cells have a different shape than the surrounding cells, and guard cells contain chloroplasts.
2. Although stomata may occur on the upper surface of leaves, they are less likely to be found there. Stomata usually are less dense on the upper surface than on the lower surface of leaves.
3. Answers will vary.
4. Stomata may not be evenly distributed on the leaf surface. Thus, counts are made so that an average can be calculated. The average of several counts is expected to be more representative of the entire surface than any one count.

Carbon Dioxide and Photosynthesis (page 156, 2 periods)

In this investigation, students will try to determine the surface of a leaf that carbon dioxide gas is most likely to enter.

Materials: 12 plants, 24 petri dishes, petroleum jelly, paper towels, 24 beakers, 6 Bunsen burners, 6 ring stands, 6 pans for water baths, alcohol, iodine solution.

If potted plants are not available, plants growing outside can be used. Those with soft leaves work best. Also, be sure to use leaves that are completely green, rather than leaves with irregular color patterns. If the plants have not been placed in the darkness for a time, it will be necessary to wait a day or so longer before picking the leaves.

The petroleum jelly can be rubbed off with paper toweling. The leaves should be dropped in boiling water to soften the tissues, before extracting the chlorophyll. (See the instructions on page 122.)

If a variety of leaves is available, students may want to test more than one kind.

Commonly, leaves have a greater density of stomata on the lower surface, so it is expected that most of them will have little or no starch when both surfaces are coated with petroleum jelly, or when the lower surface is coated. Leaves with just the upper surface coated and the uncoated leaves should have starch present in their tissues.

ANALYSIS QUESTIONS (page 156)

1. Carbon dioxide is necessary as a raw material for the production of carbohydrates.

2. Answers will vary.
3. The results of this experiment using a different kind of plant might vary, since the density of stomata on the upper and lower surfaces of leaves varies with the kind of plant.

WORD MEANINGS (page 157)

1. algae—most common food-making plants in the sea.
2. communities—populations of organisms living together.
3. consumers—organisms that must find their food.
4. leaves—the food-making centers of most common plants.
5. plankton organisms—tiny floating plants and animals.
6. seed plants—most important food makers on land

1. The growing layer of cells found in certain kinds of stems is *(d) cambium.*
2. Food-conducting tissue is called *(c) phloem.*
3. Water-conducting tissue is called *(a) xylem.*
4. The openings in plant leaves through which gases enter are called *(b) stomata.*
5. Parts that regulate the size of the openings on leaf surfaces are called *(b) guard cells.*

SELF TEST (page 158)

1. True
2. True
3. False. The boundaries of natural communities often overlap.
4. False. Simpler forms are more likely to be found surviving under a variety of different conditions than the more complex types.
5. True
6. False. Trees do not live above treeline on high mountains, but many small forms of plant life exist there.
7. False. The most common forms of algae in the sea are single-celled types.
8. False. Plankton is found in freshwater ponds and lakes, as well as in the sea.
9. False. The rock record indicates that the coast line of North America has changed.
10. True
11. False. It is thought that men did exist during the last ice age.
12. True
13. True
14. True
15. False. A root hair is an extension of a single cell.
16. True
17. True
18. False. The primary chlorophyll bearing layers are between the upper and lower surfaces in leaves.
19. False. Gases enter and leave the tissues of a leaf through stomata.
20. True

DISCUSSION QUESTIONS (page 158)

1. Since all living things need food to survive, the number of organisms in a natural community will vary directly with the quantity of food available. Thus, the greater the amount of food, the greater the number of organisms that can be supported.
2. The following lists indicate some of the kinds of organisms expected in natural communities:

   Prairie community—various grasses, annuals, low shrubs, trees, large plant-eating mammals such as bison and antelope, burrowing mammals such as gophers and ground squirrels, insects, bacteria, and fungi.

   Forest community—pines and other conifers, broad leafed deciduous trees, shrubs, ferns, deer, moose, bear, squirrels, birds, insects bacteria, and fungi.

   Deep sea community—bacteria, worms, starfish, sea anemones, shrimps, squid, and fish.

   Coastal bay community—algae, bacteria, eel grass, crabs, clams, snails, oysters, worms, and fish.
3. Because natural communities respond to local environmental conditions, and

such conditions usually change gradually rather than abruptly, the boundaries of the communities are often poorly defined and tend to merge together.

4. Bacteria, fungi, and protozoans are adapted to survive under a variety of environmental conditions. For this reason, they are found in almost every natural community.
5. In contrast to bacteria and fungi, some organisms are adapted to a special set of environmental conditions. Mountain lions are restricted largely to areas where suitable food, such as deer, is available. Fish are adapted to live only in water, and green algae cannot exist in the ocean depths, where light is not available.
6. A limiting factor is one that determines the conditions under which organisms can survive. For example, even though water, carbon dioxide, necessary minerals, and a favorable temperature exist in a cave, the growth of green plants is limited by the lack of light energy. Generally, the vital factor present in the least amount is a limiting factor.
7. Natural barriers limit the areas in which certain organisms can live by presenting a region of unfavorable conditions. Thus, a wide expanse of sea may keep organisms on one island from reaching another island, or a deep, broad canyon may prevent organisms living on either side from merging.
8. The largest organisms, like certain whales, can survive on plankton because it is available in tremendous quantities, and little energy is needed to obtain it. Large plans and animals occur in relatively small numbers in the sea, and much energy must be used to gather or to catch such food.
9. Fossil remains of marine plants and animals found in rocks reveals that much of the present land was once under the sea.
10. Climate can affect the number of plants and animals that exist in a community by its effects on the food producers. That is, if the climate is favorable for the growth of green plants, food will be available, and a large animal population can be supported. If the climate is unfavorable, few plants will survive, and only a small animal population will exist in the area.
11. Organisms adjust to climatic changes in a number of ways. Some, like certain birds, leave an area when conditions become unfavorable. Others die or become inactive, existing in retreats or surviving in resistant forms like spores and seeds.
12. Water is absorbed by the root hairs and transported to the leaves through ducts in the roots and stems. Carbon dioxide enters through openings in the leaves and stems. In the presence of light, chlorophyll bearing cells in these parts carry on foodmaking.
13. The root cap is a tip of loosely packed cells which protects the growing point, as it pushes through the soil. Root hairs are projections from surface cells that function in the absorption of water and dissolved minerals from the soil.
14. The stem functions to raise and hold leaves up in the light. In some plants, like certain cacti, the stems act as the food-making centers and as a storage place for water. In still other plants, stems are used to store food. The Irish potato is an example of a stem that stores food. In this case, however, it is an underground stem.
15. The cambium layer in a woody stem produces phloem tissue on the outside, toward the bark, and xylem tissue on the inside, toward the center of the stem. In the spring and early summer, when conditions are favorable, growth is more rapid and the cells produced are larger than in the late summer and winter, when conditions are less favorable. Thus, seasonal differences are evident in the texture of the wood produced. These texture differences can be seen as annual rings in the cross

section of woody stems and tree trunks.

16. Among the ways the structure of a green leaf is related to its functions are the following:
    a) The blade is broad and thin. As a result, a maximum number of cells are exposed to sunlight.
    b) The vascular bundles in the veins distribute water to the leaf cells and carry the photosynthetic products away.
    c) The chlorophyll bearing cells are supplied with carbon dioxide by diffusion through openings in the leaf surfaces.
17. The statement, "All life is dependent upon green plants," reflects the fact that photosynthesis is the basic source of food for life on earth. Organisms that cannot make their own foods must obtain food by eating green plants or by eating organisms that have obtained energy from green plants.
18. As stomata provide openings through which water can evaporate and thus be lost to the plant, one would expect that desert plants would have fewer rather than greater numbers of stomata than plants that grow in moist regions.

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CHAPTER 7 Community Relationships

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	In a natural community, physical conditions and populations of organisms vary constantly. From the standpoint of food alone, the lives of organisms are closely interrelated.	Types of Higher Plants (p. 261)
2. The Food Groups	The foodmakers are plants that carry on photosynthesis and simple organisms that carry on chemosynthesis.	
A. The plant eaters	Plant eating animals are called herbivores.	Plant Foods and Man (p. 261)
B. The flesh eaters	Flesh eaters are called carnivores.	
C. Animals that eat many things	Animals that eat a variety of plants and animals are called omnivores.	
D. The parasites	Parasites are organisms that feed on the tissues of a host plant or animal.	Tapeworms and Roundworms (p. 165)
E. Eaters of dead plants and animals	Bacteria and fungi that obtain energy from the bodies of dead organisms are called saprophytes. In any community, all of the food groups are likely to be represented.	
3. Community Food Chains		Laboratory Communities (p. 168) Things To Do, #1 (p. 177)
A. Food chains in ponds	In a natural community, each living thing represents a link in a complex series of food chains, through which food is passed from one organism to another. Each organism in a food chain uses some of the energy, so that the available amount grows smaller and smaller as the chain becomes longer. Man also is a link in various food chains.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
B. Other food chains	Food chains exist in all communities.	
C. The web of life	Organisms in a community interact in many subtle ways. The relationships form a complex web of life.	
4. Successions in Nature	Populations change as the environment changes. The organisms best adapted to the conditions at a given time are the ones that tend to survive.	Population Changes (p. 262) Things To Do, #2, 3, 4 (p. 177)
A. Living things change the environment	Living things affect the environment as well as being affected by it.	Things To Do, #5 (p. 177)
B. The nature of succession	A succession begins when forest land is cleared by man or fire. In time, plants appear that will maintain themselves unless environmental changes are marked. Succession of animal populations follow the succession of plants.	
C. The balance in nature	In the climax community, a balance in nature may be established in which no consumer group threatens the survival of other groups. The relative number of food makers and consumers remains about the same.	Things To Do, #7 (p. 177)
D. Man and the balance in nature	Man usually acts to disrupt the balance among food groups. Once the balance in nature is upset, it is difficult to reestablish in its original form. Although a new balance may develop in time, its nature is difficult to predict or control. It is possible for man to live in a community that is reasonably well balanced, but this requires wise use of the land.	Things To Do, #6 (p. 177)

RELATED FILMS

	Min.		
The Community	11	B&W Color	EBF
Succession: From Sand Dune to Forest	16	B&W Color	EBF
The Grasslands	17	B&W Color	EBF
Limnology	28	Color	McGraw
Life in a Woodlot	17	Color	NFBC
World in a Marsh	22	Color	NFBC

OVERVIEW AND RATIONALE

Chapter 6 developed the idea of green plants as the basic source of food for all living things. Chapter 7 builds upon this idea by discussing food relationships that exist within natural communities. Various food groups are identified—the plant eaters, the flesh eaters, animals that eat many things, parasites, and eaters of dead organisms. This is followed by a description of certain food chains and a complex of relationships called the web of life.

The last part of the chapter relates to populations and natural communities interacting with their environments in still other ways. How living things affect the environment, how communities change as conditions change, and how a balance in nature may be established are discussed. This section ends with a description of the difficulties encountered when man disrupts the balance in nature and trys to reestablish the balance. This problem points to the need for a wise use of the land.

GETTING STARTED

As Chapter 7 concerns community relationships, you might introduce this study by having your students set up individual laboratory communities in which various relationships can be observed. Such an investigation is presented on page 262. It consists of establishing a community of microorganisms in a small jar. Students should be able to note food relationships within the community, as well as a succession in the populations.

This activity can be carried on throughout the study of Chapter 7. If the communities are checked daily or every few days, student observations can be related directly to the text, for they will see evidence of food groups, food chains, and succession. If algae become established in the community, students also may note a sort of balance that may develop in time.

As an alternate or additional way to introduce Chapter 7, have your students establish the laboratory communities described on page 168. They should be able to predict the results and provide reasons for their predictions. Then the investigation can be performed to confirm or deny the student predictions. This procedure is, of course, somewhat similar to a biologist performing an experiment in order to test an idea or hypothesis.

CHAPTER NOTES

The Food Groups (page 161) In discussing plant eaters, you might note that the largest land animals, including the elephants, belong to this group. This is related to the fact that on land, plant food usually is more readily available than flesh. Also, it usually requires less energy to gather plant food than it does to capture prey.

Students may want to list their pets and classify them as herbivores, carnivores, or omnivores. Individual students should explain the type of food used to feed their pet, and at the same time, they may be able to describe ways in which the pet is adapted to eat this type of food.

Students may also be able to name various kinds of parasites that live on pets and discuss how these parasites affect the pets, as well as what can be done to control them. If interest is high, individuals or small groups of students might be assigned the task of checking reference books for more information about parasites and reporting their findings to the class. Still other students may want to investigate garden or crop plant parasites.

You might want to mention that examples of various saprophytes commonly can be found in a kitchen. The fungi that may be seen growing as bread mold, living on the surface of jelly or jam, or even living in a refrigerator on the surface of "left overs" are saprophytes.

Community Food Chains (page 166) Students may be interested to see who can describe the food chain with the greatest number of links. Have them include as many of the major food groups described on pages 161-164 as possible. It is important to emphasize, however, that the food relationships in a natural community usually are more complex than a food chain implies, because not one but many food chains are in operation. For this reason, it is better to think in terms of a food web.

Succession in Nature (page 169) Students may want to build displays to illustrate various kinds of successions in nature. For example, a series of models or bulletin boards can be used to illustrate the steps in a succession from rock to a climax forest. These steps should include rock, lichens growing on rock, an accumulation of small rock particles and decaying lichen, small plants such as mosses and ferns, more soil accumulations followed by annual plants, shrubs, trees, and finally the climax forest. It should be shown that the dominant vegetation at any time is related to the amount of soil that has formed.

Other students might illustrate the steps in a succession from a pond or lake to a climax forest. The steps should include aquatic plants growing in the water, an accumulation of debris on the lake bottom, which produces shallow water, sphagnum moss growths along the shores, plants with floating leaves such as water lilies, a continued filling of the lake with debris, emergent plants like reeds and cattails, grassy meadow plants, willows and shrubs, trees, and the climax forest. In each step, it should be shown that the dominant vegetation is related to the amount of water present in the area.

Be sure to emphasize the idea of a balance in nature and the fact that when a balance exists, no consumer group is large enough to threaten the survival of any other group. It is upon this idea that many modern methods of plant and animal conservation are based. The idea of a balance in nature will be built upon in future chapters.

LABORATORY SUGGESTIONS

Tapeworms and Roundworms (page 165, two periods)

The purpose of this exercise is for students to become acquainted with several examples of parasites.

Materials: 1 freshly killed fish, 1 freshly killed frog, dissecting scissors, forceps, dissecting pan, 12 prepared slides of tapeworms, 12 prepared slides of roundworms, 12 hand lenses, 24 microscopes.

The abdominal cavity of a fish or a frog can be opened with scissors. Clip the intestine loose from the stomach and remove it from the body. Open the intestine with scissors, wash out the contents into a watch glass with a little water, and have students observe the contents using hand lenses. A drop of intestinal contents also can be mounted on a blank slide and examined for the presence of protozoan parasites.

A local veterinarian may be able to supply examples of parasitic worms that have been removed from domestic animals. These can be preserved in alcohol or formalin as described on page 111.

Prepared slides of tapeworms and roundworms can be obtained from biological supply houses. Students should have no difficulty identifying the parts described in the text.

If interest is high, some students may want to find out more about parasites that affect man and domestic animals. Such topics as flukes, tapeworms, ascarid worms, hookworm, and trichina worms will make good reports. Parasites that cause malaria, amebic dysentery, and African sleeping sickness also can be studied.

ANALYSIS QUESTIONS (page 165)

1. A tapeworm must obtain food from the contents of the intestine in which it lives. However, as it has no mouth or digestive canal, food must enter the worm's body by passing through its body wall.
2. Tapeworms might affect their hosts by using food material that otherwise would be available for the host's body cells. Also, tapeworms might block the intestine or produce enough waste material to affect the host's cells.
3. Roundworms have a mouth and a digestive canal with which to take in food and process it.
4. A roundworm appears to be more complex than a tapeworm, because it has more specialized body parts, such as a mouth, digestive system, and anus.

Laboratory Communities (page 168)

This is a pair of related activities. In each, small laboratory communities are established to illustrate interactions among organisms. The first demonstrates the interaction between green plants and animals, while the second deals with a community in which the populations of bacteria are greatly and rapidly expanded.

Miniature Laboratory Communities (page 168, one period)

Materials: 36 jars with screw caps, 6 large beakers, 6 ring stands, 6 Bunsen burners, 24 small aquatic animals, 24 pieces of *Elodea*.

In order to reduce the number of jars needed for these demonstrations, have students work in pairs. They should have little difficulty setting up the experiment. Baby food jars with screw caps can be used for containers. Caution your students to be sure the boiled water has cooled to room temperature before adding the organisms. A tiny snail, crustacean, or fish can be used for the animal in jars 1 and 3. Of course, the same kind of animal should be placed in both jars. A piece of almost any green aquatic plant can be used in jars 2 and 3; use algae if they are more readily available than *Elodea*.

It is important that the jars be in a lighted place, but they should not be put where they will be heated above room temperature.

Have your students write their predictions as to what will happen in each jar, together with a reason for each prediction. These can serve as the basis for a short discussion at the beginning of the experiment and later when the experiment is completed.

It is expected that the animal in jar 1 will cease activity in a short time due to lack of oxygen in the water. The plant in jar 2 will remain green for a day or so, but probably will begin to lose its color in two to three days due to lack of carbon dioxide. The plant and animal together probably will look quite normal throughout the investigation.

After about a week, have your students reexamine their predictions to see if they were confirmed by the experimental results.

ANALYSIS QUESTIONS (page 168)

1. Answers will vary.
2. Answers will vary. The plant provides food and oxygen needed by the animal, while the animal provides carbon dioxide and chemical wastes needed by the plant.
3. Answers will vary.
4. Even though the water was boiled, some microorganisms may have survived in the form of resistant spores. Also, microorganisms may have been introduced when the plants and animals were added to the containers. If any of the organisms decayed, this is evidence that microorganisms were present.

Other Types of Laboratory Communities (page 168, one period)

Materials: 48 jars with screw caps, 48 aquatic animals, 48 pieces of *Elodea*, package of dried peas.

These jars are set up like jar 3 in the previous experiment, except that the water is not boiled. The dried seeds are added to provide food and energy so that decay bacteria can grow and reproduce rapidly. As the microorganisms increase, the water will tend to become cloudy. Conditions will become unfavorable for the green plants and the animals, as the concentrations of microorganisms increase.

Have your students discuss what they think will happen and why. They probably will predict that the seeds will decay, and that the animals will be affected by lack of oxygen. They may predict effects on the plants due to clouding of the water and production of waste chemicals by the decay organisms.

ANALYSIS QUESTIONS (page 169)

1. Answers will vary.
2. Answers will vary.
3. Since jar 1 in this experiment contained green plant material, an animal, and a small number of microorganisms, it probably showed the least amount of change and would be the most nearly balanced of the laboratory communities.

WORD MEANINGS (page 174)

1. balance in nature—a situation in which the relative numbers of foodmakers and consumers remains about the same.
2. carnivore—a flesh eater.
3. climax community—a group of populations that can maintain themselves over a long period of time.
4. food chain—a series of organisms through which food material is passed.
5. herbivore—a plant eater.
6. host—an organism fed upon by a parasite.
7. omnivore—an organism that eats a variety of both plant and animal tissues.
8. parasite—small organism that lives at the expense of some other plant or animal.
9. saprophyte—a nongreen plant that causes decay.
10. succession—a series of progressive changes in community populations.

SELF TEST (page 175)

1. True
2. False. Pound for pound, animal tissue is more nourishing than plant food.
3. True
4. False. Foxes and minks are carnivores.
5. True
6. True
7. False. Parasites harm their hosts and give nothing in return.
8. True
9. False. The oldest and largest segment of a tapeworm's body is at the tail end, away from the head.
10. False. Parasitic roundworms have a digestive canal.
11. False. The way in which food is passed from one organism to another is called a food chain.
12. True
13. False. Organisms may not act in an artificial community as they do in a natural community.
14. True
15. True
16. True
17. True
18. False. Living things affect the environment, as well as being affected by it.
19. False. White pines and hemlocks are dominant forms in certain forests because they are the tallest plants adapted to the prevailing conditions in these areas.
20. False. When a white pine-hemlock forest is cut down, it cannot be restored for a hundred or perhaps 150 years.
21. False. The climax vegetation is usually the last vegetation to appear in the succession following the destruction of a forest.
22. True
23. True
24. True
25. False. Once the balance of a natural community has been upset, it is usua-

ally very difficult for man to restore the balance to its original form.

DISCUSSION QUESTIONS (page 176)

1. Some consumers are limited to certain foods by the adaptations of their body parts. Herbivores, like horses, cows, and deer, for example, have front teeth specially fitted to bite grass and rear teeth with flat surfaces for grinding plant materials. The digestive systems of these animals also are adapted to processing plant foods. On the other hand, carnivores, like dogs and cats, have some sharp, pointed front teeth that are used to kill prey, and rear teeth for cutting meat into small pieces.
2. Photosynthesis and chemosynthesis are processes by which living things make food. In both, carbon dioxide and water are used to produce simple sugar and a by-product, oxygen. In photosynthesis, which requires the presence of chlorophyll, light energy is used. In chemosynthesis, the necessary energy is obtained by the combining of some substance, like iron or sulfur, with oxygen. In this process, chlorophyll is not involved.
3. Pound for pound, plant materials usually are less nourishing than animal tissues. Plant tissue contains a large amount of cell wall material that cannot be digested by most animals, and therefore this substance passes through the animal body largely unchanged.
4. There is an advantage in raising domestic animals that are plant eaters, rather than animal eaters, in that plant food is more plentiful. Also, many plant eaters can be raised on crops that man does not eat, so that the domestic animals are not in direct competition with man for food.
5. When something decays, it is being digested and fed upon by saprophytes, such as bacteria and fungi.
6. Only certain chemicals in the air and soil are of use to living things. Since these vital substances occur in limited qualitites, they must be used again and again if future organisms are to survive. For example, as a plant grows chemicals are extracted from the air and soil, and they are temporarily trapped in the plant body. After the plant dies, decay organisms decompose the plant body, and the "trapped" chemicals are released to be used again by other growing organisms.
7. Tapeworms and parasitic roundworms are alike in that they rely on a host organism for their food supply and a favorable place to live. Neither of these parasites aids the host in any way, and they may harm the host. The worms are classified in different phyla. A tapeworm is a flatworm with no mouth or digestive canal. A roundworm has both a mouth and a digestive canal.
8. Each of the following represents a food chain that might exist in a natural community:

   Forest community food chain—green plant, deer, mountain lion, bacteria.

   Ocean community food chain—green algae, small crustacean, small fish, large fish, bacteria.

   Desert community food chain—green plant, insect, lizard, snake, bird, fox, bacteria.
9. The food relationships within a natural community might be described as a web, because the animals often eat more than one kind of food and, in turn, are eaten by more than one kind of predator.
10. "The amount of food energy passed along grows smaller and smaller as the chain becomes larger" means that each organism in a food chain uses up some of the available energy to stay alive. Then it passes on less energy to a predator than it received from the food it had consumed.
11. Living things may alter their environment in a number of ways. As plants and animals die and decay, the soil is changed. Beavers build dams that create lakes which may flood lowlands

nearby. Green plants, over countless years, have increased the oxygen concentration in the atmosphere. The growth of plant roots may cause rocks to split apart. Earthworms and other soil dwelling animals move and mix large quantities of soil particles. The shade from trees lowers the temperature in local areas. And, human activities change large parts of the land area.

12. Man has upset the balance in nature many times and in many ways. He has destroyed whole forest communities by cutting down trees. He has introduced plants and animals into communities where they do not occur naturally and where they have no natural controls on their numbers. As a result, the new forms have become overpopulated and destructive to the natural balance. Man has allowed domesticated animals to "overgraze" grassland communities, which have, in turn, become "dust bowls." He has dumped wastes into freshwater streams and rivers, and in this way, he has destroyed freshwater communities. Similar destruction has occurred in the ocean communities at the mouths of such rivers.

    Many of these unfortunate results could have been prevented by wiser use of the land. On hillsides and rough land, forests should be carefully tended, and trees replanted to replace those removed. New forms of life should not be introduced into natural communities without careful study of the possible effects. Grasslands should not be "overgrazed," and wastes should be treated before being dumped into waterways.

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CHAPTER 8 Physical Factors and Life

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Many organisms are adapted to particular habitats. Habitats vary with the physical factors of the environment.	Air and Plant Growth (p. 191) Investigating a Factor in Plant Growth (p. 261)
2. Temperature Effects	Organisms are adapted to survive in a variety of temperatures, but most are favored in the range between 40°F and 105°F. Extreme heat and cold are barriers.	Temperature and the Growth of Bacteria (p. 182)
A. Warm-blooded animals	Warm-blooded animals maintain body temperatures without respect to the temperatures around them. Such animals may remain active in low environmental temperatures.	Things To Do, #2 (p. 197)
B. Cold-blooded animals	Cold-blooded organisms have body temperatures that change as the environmental temperature changes. They are inactive at low temperatures. Plants exist much like cold-blooded animals. Some forms survive seasonal low temperatures in the form of spores, seeds, or eggs.	Things To Do, #1 (p. 197)
C. Human reaction to temperature changes	Discomfort depends upon the amount of water vapor in air, as well as the air temperature. As perspiration evaporates, body heat is lost.	Things To Do, #3 (p. 197)
3. Water and Life	Water makes up a large part of living material.	
A. Water is essential to active life	Organisms in desert communities are adapted to live where water supplies are low. They may store water when it is available, rely on get-	Things To Do, #4 (p. 197)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	ting water from their food, or conserve water obtained by the chemical breakdown of fats and carbohydrates.	
B. The water cycle	Water evaporates, condenses to form clouds, falls to the earth as rain or snow, and evaporates again.	Things To Do, #5 (p. 197)
C. The water table	If there is much ground water in the soil, the water table will be high, and the surface of the soil will be moist. When the water table falls, plants may fail to survive.	Water Absorption and Water Retention (p. 263)
D. Water supplies	Crops can be grown on desert lands if fresh water is available. Where water is scarce, populations are small.	Things To Do, #6 and 7 (pp. 197-198)
4. Pressure Effects	Most living things are found at or near the earth's surface. Pressure changes as you go up or down from sea level.	
A. The deep sea community	Some organisms are adapted to live under great pressure in the deep sea. Dead organisms make up the basic food supply in the deep sea community.	
B. Human reaction to high pressure	When men in diving gear go under the sea, they must be supplied with air under pressure in order to breathe. If the pressure of the air is released suddenly, caisson disease may result.	
C. Reactions to lowered pressure	When you move up above sea level, air pressure decreases and less oxygen enters the blood. In time, the body may adjust to living at altitudes of 5000 to 15,000 feet. Sea level pressure is maintained in high flying airplanes to protect the passengers against low pressure effects.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
5. Rocks and Soils	Rock surfaces are changed constantly by natural forces.	
A. How soils are formed	Soil is produced from rock fragments and decay products. Topsoil usually is the most fertile layer.	
B. Types of soils	Soils may be described as gravels, sands, clays, loams, and silts. We depend on loam for raising crop plants. Loam is a mixture of all the other soil types.	Acid and Alkaline Soils (p. 264) Things To Do, #8 (p. 198)
C. Soil erosion	Erosion is the process whereby rocks and soils are worn away. It is brought about by the action of wind and running water. Unwise use of the land speeds erosion.	

RELATED FILMS

	Min.		
The High Arctic Biome	23	B&W Color	EBF
The Sea	26	B&W Color	EBF
The Cave Community	13	B&W Color	EBF
Our Soil Resources	11	B&W	EBF
Limiting Factors	28	Color	McGraw
Marine Ecology	28	Color	McGraw
Applied Ecology	28	Color	McGraw

OVERVIEW AND RATIONALE

The first two chapters of this block deal with biological factors of the environment and how they are interrelated within the natural community. Chapter 8 emphasizes the physical factors of the environment and their effect on living things.

Ways in which habitats vary with physical conditions and ways various kinds of organisms respond to temperature, moisture, and pressure effects are described. In addition, such processes as the water cycle, soil formation, and erosion are discussed.

The general picture is one of constantly varying physical factors, and corresponding adjustments of populations to meet the new conditions of life. Some of the physical changes and population adjustments are relatively minor; others are far-reaching in their effects.

GETTING STARTED

This chapter might be introduced with a discussion or review of the physical factors of the environment as described in Chapter 1. Students can be asked to identify the physical factors in the classroom and ways they affect living things. If there are some potted plants in the room, you might use them as examples of organisms in developing the discussion. What physical factors affect these plants? In what ways are they affected? Or more specifically, does oxygen in the air affect the plants? How about the carbon dioxide?

How do we know? How sure are we about these effects? How can our answers be checked experimentally?

This sort of discussion can lead to a laboratory activity such as the one described on page 191, *Air and Plant Growth.* This activity concerns testing some of the effects of oxygen and carbon dioxide on bean seedlings. On page 261 there is another laboratory activity which involves testing the effect of a physical factor on plants. It is called *Investigating a Factor in Plant Growth* and is a study of the effect of soil depth on sprouting seeds.

You might have interested individuals or small groups of students set up these experiments so that they can be watched throughout the study of Chapter 8.

CHAPTER NOTES

Temperature Effects (page 179) When you discuss the nature of warm-blooded and cold-blooded animals, you might want to point out that the body temperature of a cold-blooded animal may be higher than that of a warm-blooded one in the same environment. This is due to the fact that cold-blooded animals have body temperatures that vary with the surroundings. Thus, if the air around a desert lizard was 110°F, the animal's body temperature might be 100°F or more. A healthy man in the same desert air probably would maintain a body temperature close to 98.6°F.

Students may be interested to see if their temperatures vary during the day. If several individuals know how to use a clinical thermometer, have them measure and record their oral temperatures every hour for a day. This might be done at home over a weekend. If the temperature pattern is found to vary, you might want to have the class plot the temperature data on graph paper. Have the students use body temperature in degrees F as the units of the vertical axis, and the hour of the day as the units of the horizontal axis.

Water and Life (page 183) An interesting account of ways in which plants are adapted to dry desert conditions can be found in the April 1955 edition of *Scientific American* magazine. The article is called "The Ecology of Desert Plants" and was written by Dr. Frits W. Went.

Students may be interested in checking reference books for more information concerning how animals are adapted to living conditions in dry areas. Have individuals report on the structures and behavior patterns of such organisms as camels, ostriches, tortoises, horned lizards, lung fishes, toads, or kangaroo rats that seem to be related to survival in a dry environment.

Students may also want to discuss the problems facing humans who want to inhabit desert regions or the problems of survival when someone is accidently stranded on a desert.

Pressure Effects (page 187) You may want to demonstrate a physical effect of air pressure to illustrate that the pressure around us is considerable. One of the best ways to do this is to use a one gallon, rectangular can, such as a solvent container. The pressure of the air on the outside of the can will crush it, if the air on the inside is withdrawn. The air inside of the can may be removed by using either of the following methods:

a) If a vacuum pump is available, connect it to the can by means of a piece of heavy rubber tubing, a section of glass or metal tubing, and a one-hole rubber stopper. Use the pump to withdraw the air, and the can will collapse.

b) Boil about 100 ml of water in the unstoppered can. When steam begins to be produced in quantity, remove the heat source, stopper the can tightly, and allow it to cool. As the can cools, the steam inside will condense to water, and this will produce a partial vacuum inside. Air pressure on the outside will cause the can to collapse.

Students may want to calculate the total pressure acting on the outside of an empty can. They can do this by measuring the sides and determining the total surface area in square inches. Have them assume that the air pressure is 14.7 pounds per square inch for their calculations. Also have them calculate the total pressure that would be acting on the outside of an empty can at various depths in the sea, such as 10 feet, 100 feet, 1000 feet, one mile, or five miles.

Interested students may want to read about the pressure problems involved in deep sea exploration. Others may want to investigate the problems of maintaining pressure in airplanes flying at high altitudes or in manned space crafts.

LABORATORY SUGGESTIONS

Temperatures and the Growth of Bacteria (page 182, two periods)

This exercise will demonstrate that the rate of bacterial growth is directly related to the environmental temperature.

Materials: 1 quart of milk, 3 large jars with screw caps, 24 test tubes, 24 cork stoppers, methylene blue stain.

Have the students work in groups of three. Then each student can set up one of the test tubes each time a test is performed.

Methylene blue stain is blue in the presence of oxygen, and it is converted to a colorless form as the oxygen is removed. Since bacteria use oxygen, the greater the number present in the milk sample, the more rapid the color change will be. Good milk will not decolorize the stain for several hours, while milk with a greatly increased bacteria population will decolorize the stain in an hour or so.

Prepare methylene blue stain by dissolving 0.1 grams of powder in two liters of distilled water. After the milk is divided into three large jars with screw caps, be sure to keep each jar at a distinctly different temperature. Keep one in a refrigerator if possible, one at room temperature, and one at a temperature about 10°C above room temperature.

If color changes are not noted within the class period, try to arrange for a few students to check the samples each hour during the day, and record their observations for the class.

The warmer samples are expected to decolorize first, followed by the samples at room temperature. The refrigerated samples probably will not decolorize until some time later.

ANALYSIS QUESTIONS (page 183)

1. The refrigerated samples appear to have the smallest populations of bacteria, while the warmer samples have the largest populations. This difference is due to the fact that up to a point bacteria reproduce more rapidly at the higher temperatures.
2. Refrigeration seems to be an effective means of slowing the growth of microorganisms. The observation that refrigerated samples decolorize more slowly than warm samples supports this conclusion.
3. Answers will vary. The effect of boiling milk on the growth of bacteria could be tested by boiling a sample in a cotton plugged test tube, allowing it to cool, and adding methylene blue stain. An unboiled sample could be kept as a control. Both samples could be left in a warm place, and the time it takes for the stain to decolorize could be recorded.

Air and Plant Growth (page 191, one period)

The purpose of this experiment is to test the effect of oxygen and carbon dioxide on plant growth.

Materials: 24 widemouth jars with screw caps, soil, bean seeds, paraffin, tape, steel wool, soda lime, 6 glass vials.

Have students work in groups of four. Each student can set up one of the jars for this experiment.

Peanut butter jars or one-quart mason jars will be satisfactory for these tests. Any rapidly sprouting type of seed can be used. Soak the seeds in water overnight to speed sprouting. Then plant them in moist sand, loamy soil, or vermiculite. Be sure the soil is moist, but not muddy, before sealing the caps on the jars. A wad of steel wool can be fastened to the inside top of one jar using tape or wax. The steel wool should be moistened with water before sealing the jar. This will hasten the removal of oxygen from the air inside. The oxygen will combine with the iron of the steel wool to form iron oxide.

Soda lime can be purchased from a chemical supply house, and will remove carbon dioxide from the air in the jar by absorbing it. Soda lime is a solid, and can be placed in any small glass container with a wide mouth that will fit into the test jar.

Paraffin can be melted in a tin can and applied to the space between the glass and the cap with an old paint brush. This will insure an air-tight seal.

As soon as the jars are set up, ask your students to write predictions as to what will happen in each jar, together with a reason for each prediction.

It is expected that the plants will grow well in all the jars except the one containing the soda lime.

ANALYSIS QUESTIONS (page 191)

1. Answers will vary. It is probable, however, that plant growth will be inhibited in the jar containing the soda lime.
2. Lack of oxygen does not seem to affect the growth of a green plant.
3. Lack of carbon dioxide seems to inhibit the growth of a green plant.
4. Green plants need carbon dioxide from the air in order to grow.

WORD MEANINGS (page 195)

1. "bends"—disease due to nitrogen bubbles in the blood and tissues.
2. caisson—sealed chamber containing air under high pressure.
3. cold-blooded—organism with body temperature that changes with temperature changes of the environment.
4. erosion—process by which land is worn away.
5. ground water—water held in rocks and soil.
6. habitat—particular environment to which an organism is adapted.
7. topsoil—mixture of rock fragments and decay products.
8. water table—upper level of ground water.

1. Soil that is made up of particles that have been carried in water and then deposited is called (*c*) *silt.*
2. Soil that is composed of exceedingly fine-grained particles of a particular type of rock is called (*b*) *clay.*
3. Soil composed of large rock fragments is called (*c*) *gravel.*
4. Soil made up of a mixture of soil types is called (*a*) *loam.*
5. Soil composed of very small rock fragments is called (*d*) *sand.*

SELF TEST (page 195)

1. True
2. False. Some bacteria have survived boiling, and some seeds have sprouted after being exposed to temperatures well above the boiling point.
3. False. The fact that water has been frozen is no guarantee that it is free of disease-producing organisms.
4. True
5. True
6. True
7. False. Perspiration evaporates more rapidly on a warm day when there is little water vapor in the air, than on a warm day when there is much water vapor in the air.
8. True
9. False. About two-thirds of the human body is made up of water.
10. False. Some desert animals rely on water obtained from moist food, while others get much of their water from the chemical breakdown of fats and carbohydrates in dry seeds that they eat.
11. True
12. True

13. False Desert soil often is fertile, but crops are not grown because of lack of water.
14. True
15. True
16. False. For every 31 feet of sea water, the pressure increases about 15 pounds per square inch.
17. False. Dead organisms make up the basic food supply of the deep sea community.
18. True
19. False. Altitude sickness is caused by remaining too long in low pressure where there is an inadequate supply of oxygen for the body cells.
20. False. Wet steel wool can be used to remove oxygen from the air in a sealed jar.
21. True
22. True
23. True

DISCUSSION QUESTIONS (page 196)

1. The light conditions and the amount of oxygen and carbon dioxide in the air might be similar in desert and jungle areas. However, the desert is marked by very little rainfall and thus water is lacking in sufficient quantity for much plant growth. Jungle areas usually have much rainfall. Also, as a result of lack of atmospheric water, deserts are subjected to great changes in temperature. That is, it may be very hot during the daytime and quite cold at night. In the jungle, the temperatures will not vary as much from day to night. Because of the abundant plant growth in the jungle, the soil will contain much more decay products than will desert soils.
2. Because warm-blooded animals have a body temperature that is relatively independent of the environment, they can remain active even though the outside temperature is low.
3. Plants are similar to cold-blooded animals in that their body temperature varies directly with the environment. As a result, when the outside temperature is low, plants are rather inactive and their life processes are carried on at a reduced rate.
4. Some organisms survive the cold of winter by remaining active and continuing to search for food. Others migrate to warmer climates or locate retreats in which to stay until milder conditions return. Still other forms die in severe weather. Some will leave spores, seeds, or eggs that can resist the effects of cold weather and will reestablish the species the following spring.
5. You feel more comfortable in dry air at 95°F than in moist air at the same temperature, because your perspiration evaporates more readily in dry air, and as it evaporates, it takes body heat with it.
6. The stain methylene blue is a blue color in the presence of oxygen and colorless in its absence. Since bacteria use oxygen, the rate at which the stain becomes decolorized can be used as an indication of the relative size of the bacterial population present in a sample.
7. Some forms of life can survive in dry desert areas by obtaining water from their food. Certain organisms eat moist plant and animal tissues, while others obtain water as a by-product of the chemical breakdown of the materials in dry seeds. Still other organisms take in water when it is available, and store it in specialized tissues. Many plants and animals remain inactive when water supplies are low, and then resume activity when the rains fall.
8. "Water cycle" refers to the continual movement of water which falls as rain, covers various parts of the earth's surface, evaporates into the air, condenses into clouds, and falls as rain again.
9. The water table rises as rain seeps into the soil and becomes ground water. It falls, as the ground water moves downhill toward the sea, as plant roots absorb water, as ground water evaporates

into the air, and as water is lifted out of wells.

10. One of the biggest problems facing people who are interested in changing desert areas into farmlands is that of obtaining a sufficient water supply. Also, some desert soils are low in decay products which are important to plant growth and to the water-holding capacity of soil.
11. In order to live in an area of high pressure, an organism must maintain an equally high internal pressure. If such an organism moves rapidly from an area of high pressure to an area of low pressure, tissues which have high internal pressure will tend to expand. These expanding parts may burst unless the pressure inside of them is lowered.
12. In order for men to work at even moderate depths in the sea, they must breathe air under pressure. Thus, the pressure inside of their diving suits must offset the pressure on the outside, if they are to breathe and move about.
13. "The bends," or caisson disease, is developed when air under high pressure is breathed and then the pressure is released suddenly. When this happens, bubbles of nitrogen gas form in the blood, block blood vessels and press on nerves. This condition can be prevented by releasing the pressure gradually so that excess nitrogen in the tissues is discharged through the lungs at a gradual pace and nitrogen bubbles do not form.
14. Discomfort may be felt by people who move from sea level to high altitudes because, in the reduced air pressure, less oxygen enters the blood through the lungs. Then the body cells have a lowered oxygen supply. The discomfort may be reduced by remaining as inactive as possible. In time, the body adjusts to conditions of lowered air pressure.
15. Soil formation begins as rock surfaces are worn away by the action of wind and water. As tiny particles accumulate, plants may begin growing in the rock fragments. Plants and animals die and their remains decay. The decay products are gradually mixed with the rock material and a layer of topsoil develops.
16. Land erosion is favored by factors that remove the protective layer of plants from the land surface. For example, overgrazing of grasslands by herbivores, and the destruction of forests by men and fire speed erosion by exposing the soil to the action of wind and water.

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CHAPTER 9 Special Adaptations

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	All living things are adapted to their environments. Adaptations may depend on body structures and ways of behaving.	Adaptations of a Snail (p. 204)
2. Adaptations and Survival	Organisms that cannot adjust to a changing environment do not survive. Adaptations are the result of hereditary changes in a species.	Adaptations of a Fish (p. 267) Things To Do, #5 (p. 217)
A. Cyst formation	Some organisms survive unfavorable conditions by forming cysts.	Things To Do, #1 (p. 217)
B. Spore formation	Bacteria may survive unfavorable conditions by forming spores.	
C. The lung fishes	Lung fishes have lunglike tissue in their swim bladders with which they can obtain oxygen from air when the need arises.	
D. Protective coloration	Some animals avoid predators because their color pattern blends with their surroundings.	Things To Do, #2 (p. 217)
E. Mimicry	Mimicry involves resemblance in form as well as in coloration.	
F. An ink-screen defense	Squids and octopuses may escape predators by releasing an ink cloud.	
G. Animals with electric organs	Certain animals have electric organs capable of generating an electric charge which can be delivered when the need arises.	
H. Adaptations of desert plants	Deserts are dry areas where the temperature varies greatly. Desert plants may survive by storing water and by having reduced leaf surfaces.	Root Growth and Structure (p. 264)
3. Adaptations and Food	Obtaining adequate food supplies is essential to the	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	well-being of all living things.	
A. A starfish eats a clam	A starfish is adapted to opening the shell of a clam and feeding on its fleshy parts.	Adaptations of a Starfish (p. 266)
B. A deep-sea angler	The deep-sea angler is adapted to luring prey into its jaws by means of light producing organs.	
C. Plants that are carnivorous	Some plants supplement their food supplies with protein obtained from the bodies of small animals.	
D. Teeth and foods	The teeth of an animal generally are adapted to the type of food they eat. Plant eaters often have teeth shaped for grinding, while meat eaters have pointed teeth for holding prey.	Things To Do, #3 (p. 217)
E. The bills of birds	Bird bills are adapted to the type of food eaten. For example, predatory birds often have sharp, hooked bills for tearing flesh.	
4. Adaptations for Flight	Some organisms are adapted to traveling in air by being blown along.	
A. Insect flight	Insects probably were the first animals to fly. Insect wings are operated by muscles inside of their hard outer covering. These wings are modifications of the external skeleton and respiratory system.	
B. The flight of birds	Bird wings are modified front limbs covered with feathers. A bird's muscles, skeleton, and lungs are adapted to flight in special ways.	The Bird Skeleton (p. 212) Things To Do, #4 (p. 217)
C. The flight of bats	Bats are flying mammals. The bat's wings are modified limbs and skin. While in flight, bats may locate objects by echoes from high pitched cries.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
5. Adaptations and Reproduction		
A. West coast salmon runs	Salmon live in the sea most of their lives, but they move into fresh water to reproduce.	
B. Some other fish adaptations	Eels are freshwater fish that enter the sea to reproduce.	
C. Surinam toads	The young of the surinam toads develop in "skin pockets" on the back of the female parent.	

RELATED FILMS

	Min.		
Natural Selection and Adaptation	28	Color	McGraw
Asexual Reproduction	16	Color	IU
Adaptive Radiation: The Mollusks	18	B&W Color	EBF
Fungi	16	B&W Color	EBF
What is a Bird?	17	B&W Color	EBF
What is a Fish?	16	B&W Color	EBF
The Desert	22	B&W Color	EBF
Echinoderms: Sea Stars and Their Relatives	17	B&W Color	EBF

OVERVIEW AND RATIONALE

Chapter 9 continues to develop the major theme of Block II, interaction among the living and nonliving factors in the natural community. Attention is focused on the ways in which organisms are adapted or specially fitted by the presence of certain structures or patterns of behavior to survive in particular environments.

Microorganisms, lung fishes, and desert plants are used as examples of organisms adapted to dry conditions and extreme temperatures. Ways in which animals avoid predators by protective coloration, mimicry, ink screens, and electric organs are presented. This is followed by a section dealing with adaptations for capturing and eating special foods, and a section concerning adaptations of body parts for flight.

The chapter ends with a discussion of specialized behavior relating to reproduction in such animals as salmon, eels, sea horses, and certain toads. This part serves to introduce Chapter 10, which concerns other adaptive patterns of behavior.

GETTING STARTED

An interesting way to start a detailed study of adaptations is to select an organism and examine it for the presence of adaptations in structure and behavior. The laboratory activity, *Adaptations of a Snail,* on page 204 might be used for this purpose.

You may want to begin by reviewing the idea of adaptations, and have students discuss ways in which their bodies are adapted to survive on the land in relatively dry air. This can lead to a discussion of ways in which other familiar organisms are fitted for special environments. How are fish adapted to the aquatic environment? How are certain monkeys adapted to live in trees? How are moles adapted to live underground?

When the idea of adaptation is well in mind, have your students carry out the snail investigation. This can be followed with the study of *Adaptations of a Fish*, page 267.

Be sure to emphasize that plants have adaptations too. To illustrate this point, you might have the students consider how plant parts, such as roots, are adapted to conditions on the land. Such a discussion can be followed by the laboratory investigation, *Root Growth and Structure*, page 264.

CHAPTER NOTES

Adaptations and survival (page 199)— When you discuss the idea that an organism cannot develop new structures just because it needs them, you might want to use the example of the extinct dinosaurs. One theory holds that the dinosaurs disappeared because they were unable to adapt to a changing environment. The ways in which the hereditary changes, needed for the development of new adaptations, may come about are described in Chapter 22.

Students may be interested to know that bacterial spores are extremely resistant to drying, and that some kinds can survive for many hours in boiling water. As a consequence, sterilization procedures used in laboratories and hospitals are designed specifically to destroy spores. All spores can be killed by exposing them to pressurized steam at a temperature between 115°C and 120°C for about 20 minutes.

Ask students to list examples of protective coloration that they have observed or have heard about. Have them include examples from several different animal groups, such as insects, fishes, birds, and mammals. For each example, ask the student to mention the conditions of the natural environment related to the adaptation. You also might want to show students pictures of animals, such as zoo specimens, outside of their natural habitats, and see if students can deduce the kind of environment in which a color pattern is protective. For example, the stripes on a zebra's body blend with the light and shadows of a grassland.

Adaptations and Food (page 205) Carnivorous plants commonly live in bogs where soil nitrates are in low supply. It is thought that by obtaining nitrogen-containing proteins from animal bodies, these plants are able to survive in the bog environment. You may also want to mention that some plants are adapted to obtain food from other living things by acting as parasites. Examples of higher plants that are parasites include the dodder plant, which is a relative of the morning glory, and the mistletoe. Both of these plants parasitize various seed plants. The fungi that cause "athlete's foot" are examples of borderline organisms that live in the tissues of man.

Students may be interested in making a collection of pictures of various birds. These can be used to illustrate protective coloration, as well as adaptations of bills for eating certain foods. In addition, the legs and feet of birds often are adapted for specialized habits. For example, predatory birds, like hawks, have powerful feet and claws used for grasping prey. Chickens and ostriches have feet adapted for walking on land. Water birds often have webbed feet for paddling, while others have long legs for wading in shallow water.

Adaptations for Flight (page 209) Small insect wings make interesting objects for microscope study and students may want to make a collection of various kinds for observation. The insects can be killed by following the directions on page 109. The wings can be removed with forceps, mounted dry on slides, and covered with cover glasses. If several species of insects are available, have the students compare their structures. You may want them to consider the possibility of classifying insects on the basis of differences in wing size and structure. If many wings of one species are available, have the students look for evidence of variation within the species.

Similarly, the structure of bird feathers can be investigated. Have students compare the structure of down feathers, that are close to the skin and act to insulate the body, contour feathers, that cover the body and give it its smooth outline, and quill feathers, that grow from the wings and tail, and are used in flying. Small bits of feathers can be mounted dry on slides and covered with cover glasses for microscopic study.

LABORATORY SUGGESTIONS

Adaptations of a Snail (page 204, one period)

In this exercise, students will observe a snail's behavior, test its reaction to certain stimuli, and determine how it is adapted to survive in a dry environment.

Materials: 24 pond snails or land snails, 24 culture dishes, 3 battery jars or 3 aquariums.

It may be convenient to have students study their snails in culture dishes, rather than in aquariums or on desk tops.

If pond snails are used, they can be observed moving about and feeding on algae as they travel over the glass of an aquarium. Land snails generally will extend their bodies from their shells and move about in a culture dish or on a desk top. Since they leave a trail of slime, it is best to protect the desk top with paper or a piece of plate glass. In order to observe the land snail feeding, offer it bits of lettuce.

Students may be interested to see if snails will respond to bright light, darkness, or loud noises. Does a snail seem to prefer moving uphill, downhill, or on a level surface? Does it respond to large objects moving nearby?

When exposed to dry conditions, both land and aquatic snails generally withdraw into their shells, seal off the openings, and remain inactive until conditions become more favorable.

If snails are not available, these activities can be observed in another type of small organism. The behavior of sow bugs, earthworms, or insects such as mealworm beetles might be studied instead.

ANALYSIS QUESTIONS (page 205)

1. Snails generally feed on plant materials, using a tongue-like structure that has a rough surface like a file. However, some snails will feed on dead animal material when it is available. Thus, pond snails may be seen feeding on the bodies of dead fish.
2. Snails move about on a broad, flat, muscular foot. The land snail secretes a slimy liquid, over which it travels. The snail's eyes are located at the ends of its tentacles. It can feel objects and is sensitive to chemicals that touch its body surfaces. A snail protects itself by withdrawing into its shell and remaining inactive.
3. A snail survives dry conditions by sealing itself in its shell and remaining inactive until conditions become more favorable.

The Bird Skeleton (page 212, one period)

The purpose of this activity is to observe a bird skeleton, examine it for adaptations related to flight, and compare its structure with that of other vertebrate skeletons.

Materials: bird skeleton, cat skeleton, human skeleton, or charts of each of these skeletons can be obtained from biological supply houses.

If charts are not available, some idea of the adaptations for flying and the similarities between bird and mammal skeletons can be gained by comparing pictures or charts. Or students may be able to bring to class a few chicken or turkey bones salvaged from the dinner table. Such bones should be scraped free of all meat and thoroughly dried to prevent decay and unpleasant odors. Beef, pork, or lamb bones also may be salvaged from the dinner table. The weight of such mammal bones can be compared with that of birds. A cross section of each will reveal differences in structure related to the differences in weight.

ANALYSIS QUESTIONS (page 212)

1. A lightweight skeleton makes it easier for a bird to fly.
2. If the breast bone has no keel, to which many of the flight muscles usually are attached, the bird probably cannot fly. Such birds as the ostrich, the emu, and the kiwi lack a well developed keel and have lost the power of flight.

WORD MEANINGS (page 214)

1. An adaptation may be *(d) all of these.*
2. The function of cysts is most closely related to *(a) survival.*
3. Lung fishes can obtain oxygen only by means of *(c) gills and swim bladders.*
4. An example of mimicry is *(b) a walking-stick insect resembling a twig.*
5. Electric organs are structures found in certain species of *(c) rays.*
6. Tube feet are structures developed by *(a) starfishes.*
7. A carnivorous plant is one that *(b) can make food, but also feeds on small animals.*
8. Canine teeth are adapted to *(c) hold prey.*
9. In the following list, the animal that has a keel on its breast bone is a *(b) bird.*
10. All insects, birds, and bats are *(d) animals.*
11. Eels are *(d) freshwater fish that spawn in the sea.*
12. The Surinam toad *(b) carries its young in skin "pockets."*

SELF TEST (page 215)

1. True
2. True
3. False. Cyst formation occurs in some many-celled invertebrates, as well as in single-celled forms.
4. True
5. False. Lungfishes have gills like other fishes.
6. False. When its pond dries up, a lung fish may burrow into the mud and form a chamber with a small hole at the top.
7. True
8. True
9. False. Squids can change color quite rapidly.
10. True
11. False. About 500 different kinds of plants exhibit carnivorous tendencies.
12. True
13. True
14. False. A bird with a bill that curves sharply downward to form a sharp point probably is a flesh-eating bird.
15. True
16. False. The majority of insects can fly, but some forms are wingless.
17. True
18. True
19. False. In terms of its size, a bird's skeleton is unusually light in weight.
20. False. Birds are warm blooded.
21. False. Our North American bats are insect-eaters.
22. True
23. True
24. True
25. True
26. True
27. False. The male sea horse carries the young in a brood pouch.

DISCUSSION QUESTIONS (page 216)

1. The human body is adapted to the land environment in many ways. For example, lungs are adaptations for breathing air, the skin is adapted to prevent water loss, the legs are adapted to move the body over the land, and the eyes and ears are adapted to function in air.
2. The statement, "All plants and animals possess adaptations," means that every living thing is somehow specially fitted to survive under a particular set of environmental conditions. To support this

statement, a great number of organisms would have to be examined and found to possess adaptations, without exception.

3. Organisms may be adapted to dry conditions in a number of ways. A snake's skin is a waterproof covering that restricts water loss. A desert tortoise is adapted to feeding on moist plants from which it obtains water. Desert plants often have water storage tissues and a reduced number of leaves, which aid in water conservation. The behavior of many desert animals is adjusted to dry conditions in that they remain in cool burrows or under rocks or in the shade of shrubs during the day, and search for food at night.
4. Some animals, such as birds and mammals, are adapted to cold conditions by being warm-blooded and being covered with a blanket of fur or feathers. Some birds may migrate out of a region when conditions become severe. Other organisms, like toads and frogs, may retreat into burrows and remain inactive until conditions are more favorable. Microorganisms often survive cold by forming cysts as protective coverings.
5. In the case of protective coloration, the color and the pattern of color of the organism blends well with the surroundings. Mimicry is the case in which the form, as well as the color, of the organism resembles some part of its environment. Thus, a dead-leaf butterfly with its wings folded is shaped and colored like a brown leaf.
6. Some organisms, like rabbits, are adapted to protect themselves by hiding and depending on protective coloration. Others like walking-stick insects possess some type of mimicry. In each case, the behavior of the organism may aid it in concealment. A rabbit may remain motionless for a long period of time, while a walking-stick insect may move along very slowly. Squids and octopuses hide behind an inkscreen which they discharge when they are threatened.
7. A starfish is adapted to overcome the protective adaptation of a clam by the possession of tube feet which the starfish can attach to the outside of the clam shell and pull the shell open. Once the shell is open, the starfish is adapted to forcing its stomach out of its mouth. The stomach surrounds and digests the fleshy parts of the clam.
8. A pitcher plant is adapted to obtain animal food in the following ways.

   a) Its leaves are pitcher-shaped and near the top, hairlike spines point downward. When an insect gets into the leaf, its escape is hindered by the spines.

   b) At the bottom of the leaf is a liquid that contains enzymes. These enzymes can digest the animal victim.

   c) The cells of the leaf can absorb the products of digestion and use them to supplement their food supply.
9. "You can tell what sort of food an animal eats by examining its teeth," because teeth are usually adapted to specific types of food. For example, herbivores, like horses and cows, have sharp biting teeth in front that are used to cut off pieces of grass, and flat molars, that are used to grind such plant food. Dogs and cats have sharp pointed teeth for capturing and holding prey, and scissor-like teeth in the rear for cutting meat into small pieces.
10. Human teeth are adapted for biting and chewing a variety of food types. Our front teeth are shaped for biting off pieces of food, while our rear teeth have broad surfaces that are used for chewing.
11. Different kinds of birds often are adapted to eat special types of food by the shape of their bills. Meat eating birds, like owls and hawks, have sharply curved bills used for tearing flesh. A heron's bill is spear-like, and is used to capture fish and frogs, while seed-eating birds usually have short

powerful bills that are needed to break open hard seeds.

12. Birds, bats, spiders, insects, bacteria, and other small organisms may be found in the air from time to time. Also, products of living things, like cysts, spores, and pollen grains, are often present in the air.
13. Insect wings develop from portions of the external skeleton that grow outward and become flattened. As these wings form, tubes branching from the insect's respiratory system grow into the wings and give them support. These tubes become the veins of the wings.
14. While an insect's wings are formed from part of its external skeleton and respiratory system, the wings of a bird are modified front limbs that are covered with feathers. The bat's wings are supported largely by its front limbs with flying membranes of skin extending back to the hind limbs and tail.
15. Bird skeletons are adapted to flight in that the bones of the front limbs form the support for the wings, the long bones are hollow and light in weight, and sometimes the bones contain air sacs. In addition, birds have an extra bone, which gives the shoulder girdle firm support, and flying birds have a blade-like keel on the breast bone, to which many of the flight muscles are attached.
16. Air sacs are structures that are attached to the lungs of birds, and although they do not contain lung tissue, they can supply the lungs with air when the bird exhales. Also, excess body heat can be discharged into these sacs.
17. Air sacs might provide an extra supply of oxygen for an aquatic bird that must dive beneath the water to find food. The sacs might serve also to aid the bird in floating on the water's surface.
18. A bat's wings are formed of a skin membrane that is supported by the front limbs and stretched back to the hind limbs and tail.
19. A bat avoids colliding with objects while flying at night by uttering shrill cries which echo back from solids and warn the bat that is on a collision course.
20. When an eel moves from fresh water into the sea, it will encounter problems of adjusting to new temperatures, oxygen concentrations, and salt conditions. Also, former food supplies will not be available, and different predators will be encountered.

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CHAPTER 10 Patterns of Behavior

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS to BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Oragnisms have behavioral as well as structural adaptations.	Chemical Conditions of the Environment (p. 225) Things To Do, #1 (p. 236)
2. Hibernation	Some animals hibernate in order to survive in low temperatures.	
A. Some animals hibernate	During hibernation, an animal's life processes are carried on at a greatly reduced rate. Energy is obtained from fat tissue. Some animals remain in dens or burrows, but do not hibernate.	
3. Migration and Emigration	Migration refers to seasonal travels between summer and winter homes, while emigration means movement from one place to another without a return trip.	Things To Do, #2 (p. 236)
A. Migration of birds	Some birds migrate over long distances. Migrating birds seem to use the position of the sun and stars as guides.	
B. One of nature's puzzles	Although several explanations have been suggested, there is still some question as to why birds migrate.	
C. Mammals that migrate	Fur Seals, certain species of bats, and caribou are among the mamals that migrate.	
D. Emigrations of squirrels	Overpopulation and scarcity of food seems to be factors related to squirrel emigrations.	
E. Emigrations of lemmings	Lemming emigrations begin after a rapid increase in population numbers.	
F. Locust plagues	Locusts are grasshoppers that sometimes occur in large numbers and move across the land, destroying crops and other plants.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
4. Social Behavior	The members of some species live in groups and are adapted to social life.	
A. The termite colony	A termite colony consists of several types of individuals performing specialized functions.	Things To Do, #3 (p. 236)
B. The honeybee establishment	Honeybees also live in colonies and develop several types of castes which perform specialized functions.	Things To Do, #5, 7 (p. 237)
C. Colonies of ants	As in the case of termites and bees, the ant colony is composed of different types of individuals performing specialized functions. Some ants raise crops of fungi, others care for aphids which provide a sugary substance eaten by ants and some ants keep ants from other colonies as slaves.	Things To Do, #4, 6 (p. 231)
5. Adaptations and Behavior A. Communication	Some animals communicate with calls that indicate distress, anger, danger, or discovery of food. Bees communicate by certain patterns of body movements.	
B. Cooperation among organisms	When two different organisms are closely associated in a way that benefits both, it is called mutualism. If one profits, and the other is not harmed, the association is called commensalism.	
C. Competition	Animals often compete with other animals for food and security. Birds sometimes establish territories, which they defend against the invasion of other birds.	

RELATED FILMS

	Min.		
Behavior	28	Color	McGraw
Interrelationships for Survival	28	Color	McGraw
Social Insects: The Honeybee	24	B&W Color	EBF
Behavior in Plants and Animals	11	B&W Color	COR
Secrets of the Bee World	13	Color	Walt Disney

OVERVIEW AND RATIONALE

Chapter 9 deals primarily with adaptations in structure and color patterns; Chapter 10 continues the study of ways in which organisms are adapted to survive in particular environments, with special emphasis upon adaptations of behavior.

How animals respond to seasonal and population changes by hibernation, migration, and emigration is presented. This is followed by a section concerning social behavior in various insect groups, including termites, honeybees, and ants. In each case, the different types of individuals that perform specialized functions of value to the insect group are discussed.

Finally, the chapter takes up the topics of communication, cooperation, and competition among organisms. Such examples as communication by body movements in bees, mutualism in lichens, and termite-protozoan associations, are used to illustrate these specialized patterns of behavior.

GETTING STARTED

You might begin the study of behavioral adaptations by holding a class discussion. Have students describe specialized behavior patterns in plants and animals that they know about. Such topics as nest building, honeybee food gathering, migration of fish, spider web building, and various examples of mutualism or parasitism might be mentioned. In each case, have the students think of ways in which the behavior aids the survival of the individuals or group in its particular environment. A film, such as "Dance of the Bees" (Wilner Films and Slides) or "Behavior in Plants and Aniamls" (Coronet), might be shown to supplement this discussion.

On page 225 there is a laboratory activity called *Chemical Conditions of the Environment*. This might be used to illustrate a behavioral response to a physical condition in the surroundings of an organism.

CHAPTER NOTES

Hibernation (page 219) The topic of hibernation can be related to the state of dormancy observed in various plants during winter conditions. Although many kinds of plants escape the winter cold by ending their life cycles with the formation of seeds or spores, others continue to live and carry on their life processes at a greatly reduced rate. The loss of leaves by deciduous trees with the approach of winter is associated with the end of the food-making season for these plants.

Students may be interested to know that if the water in cells freezes, the resulting ice crystals may cause the cell membranes to break. This, of course, may cause the death of the cells. Many plants that are adapted to survive the cold are able to convert the free water in their cells into a form called "bound water" which has a lower freezing point.

Also related to hibernation is a kind of behavior observed in desert animals during the warmer, dry days of the summer. At this time, certain animals enter burrows or other hiding places, become inactive, and carry on their life processes at a reduced rate. Since this takes place in the summer, it is called estivation to distinguish it from hibernation. Certain insects, snails, and amphibians are among the animals that estivate. Various tropical animals also estivate during hot dry seasons.

Migration and Emigration (page 221) Certain butterflies and grasshoppers also are known to migrate from summer to winter homes. Another type of seasonal travel is related to reproductive behavior and can be observed in toads and land crabs. During their breeding seasons, these organisms move to special environments, where they lay eggs, and then they return to the environment where they feed and spend most of their time. For example, toads live much of their lives on land, but they return to freshwater ponds to breed. Similarly, land crabs return to the sea to breed.

Social Behavior (page 226) Ask students to discuss the advantages and disadvantages of social behavior as it is found in termites, bees, and ants. The students should note that the individuals in such societies live in a shelter where the environment is controlled to a much greater extent than would be possible if an individual insect lived alone. For example, bees are able to control the temperature of their hive to some degree. In the winter, the heat released from their bodies as they oxidize stored food raises the temperature in the hive; in summer, worker bees may fan the air with their wings and thus lower the temperature in the hive. Also, the individuals living in a society are protected against predators to a greater extent by group defense than an individual would be if it lived alone.

On the other hand, there are problems, no doubt, created by the close interactions among individuals in an insect society. The behavior of each member is influenced by other members. For example, the members are specialized to perform certain functions and, at the same time, are dependent upon other members to supply certain needs. Thus, reproductive individuals in the bee society are dependent upon the workers to supply them with food.

Adaptations and Behavior (page 231) Point out that communication among the members of a complex society, such as that found in honeybees, is important in the regulation and coordination of members' activities. Also, students may be interested in discussing the way order is regulated in flocks of certain birds. For example, it has been discovered that a chain of dominance exists within a group of hens. In such a group, there is a "peck order." This means that hen 1 can peck all of the other hens, and not be pecked by them. Hen 2 can peck all of the others, except hen 1, and hen 3 can peck all of the others, except hens 1 and 2. This pattern continues down to the "lowest" hen, who is pecked by all of the others and can peck none of them back. Similar dominance relationships are known to exist among the members in groups of certain fish, reptiles, and mammals.

Students may see a similarity between this kind of "peck order" and the "chain of command" that exists in various human social and military organizations.

LABORATORY SUGGESTIONS

Chemical Conditions in the Environment (page 225, one period)

The purpose of this activity is to test the response of small aquatic organisms to the presence of salt solutions of varying concentrations.

Materials: 24 microscopes, 24 slides, 24 cover glasses, table salt solutions of 1%, 2%, and 4% concentration, small aquatic organisms such as protozoans, water fleas, brine shrimp, or aquatic worms.

Prepare a 1% salt solution by placing one gram of table salt in a graduated cylinder and adding enough water to make 100 ml. Similarly, prepare 2% and 4% solutions using 2 and 4 grams of salt, respectively.

If time is available and student interest is high, you might suggest that they test the response of the organisms to other chemical substances. Such things as weak sugar solutions, a starch-water suspension, or a tiny bit of meat in the water can be used to test responses to "food chemicals." Or, have them try a drop of dilute acetic acid, or vinegar. In every case, the material being tested can be added to one side of the cover glass, as water from the other side is withdrawn with a bit of paper towel.

Have students watch the organisms for movements that can be interpreted as moving toward the chemical or moving away from it. Also have them watch for changes in rates of locomotion and changes in the internal movements of larger forms. If large protozoans, such as paramecium, are used, have students see if they can note any changes in the rate at which the contractile vacuoles operate.

If different kinds of chemicals are tested, it will be important to select fresh organisms and a clean slide for each test.

ANALYSIS QUESTIONS (page 225)

1. Answers will vary.
2. Answers will vary.

WORD MEANINGS (page 234)

1. hibernation—condition in which life processes slow down.
2. soldiers—caste of termites that defends the colony.
3. drones—male honeybees.
4. emigration—one way journey performed by an animal.
5. commensals—organisms that live together with no injury and perhaps some benefit to one of them.
6. fat bodies—special frog structures that contain stored food.
7. territories—home areas that various animals try to defend.
8. protozoans—organisms that live in the intestines of termites.
9. migration—two way journey performed by an animal.
10. round dance—a way in which bees indicate the location of food.
11. pollen—a food used by honeybees.
12. honeydew—a secretion of aphids.

SELF TEST (page 235)

1. True
2. False. When a leopard frog hibernates at the bottom of a pond, it obtains oxygen from the water through the blood vessels of its skin.
3. False. When a ground squirrel hibernates, its breathing and heart rate falls, while it's temperature is about that of its surroundings.
4. True
5. False. Birds that move back and forth between a summer and winter home are said to migrate.
6. False. When fur seals migrate, the old males do not take part in the journey, but remain behind and await the return of the females and young seals.
7. False. Lemming emigration usually is a response to a greatly increased population size.
8. False. The main function of the queen termite is to produce eggs and carry on reproduction for the colony.
9. False. Termites will only build a colonial home in a spot where moisture is available.
10. False. Honeybee castes include queens, workers, and drones.
11. True
12. False. In the honeybee society, workers do most of the food gathering.
13. True
14. True
15. False. Ants may take special care of aphids and feed on the honeydew that the aphids produce.
16. False. The round dance of the honeybee indicates the location of food.
17. True
18. False. Fungus growing on the roots of trees may benefit the trees.
19. False. When two animals are closely associated, and one of them suffers an injury from the other, it is a case of parasitism.
20. False. Many organisms compete with others for food and shelter.

DISCUSSION QUESTIONS (page 236)

1. By hibernating, an organism is able to remain inactive during the time when the environmental conditions are severe. In this manner, the organism may be able to survive, and can resume normal activity when conditions become more favorable.
2. During hibernation an animal's life

processes are carried on at a greatly reduced rate.

3. Migration involves seasonal travels between summer and winter homes, while emigration means to move from one place to another with no return journey.
4. Birds are thought to migrate because of habits developed during the last ice age, because food supplies become scarce in northern lands, because of changes in day length leading to greater activity, or because competition for food becomes too great.
5. Birds are thought to find their way during migrations by orienting themselves to the position of the sun and stars.
6. Emigration seems to take place in response to an increased population in the case of grey squirrels, lemmings, and locusts.
7. In a termite colony, there are the following castes: queen, kings, workers, and soldiers. The queen and kings are responsible for reproducing the colony; the workers build the tunnels and feed and care for the queen as well as the young; the soldiers protect the colony.
8. Some termites raise fungi in their colonies. The leaf-cutter ants also provide an example of an insect that raises fungi.
9. Termite colonies live in the wood of buildings or in the trunks and roots of trees. They build colonies only in places where moist soil is available nearby.
10. In the honeybee colony, there are workers, drones, and a queen. The queen and drones carry on reproduction, while the workers build the hive, act as nurses for the young, collect food and water, and control the temperature of the hive.
11. Ant castes are similar to termite and honeybee castes in that there are queens and males who reproduce for the colony, and workers who act as builders, nurses, and food gatherers. The ant societies differ in that there may be several queens in a colony. Also, the males only appear during the reproductive season, and often there are several special types of workers.
12. Soldier ants go on food seeking marches. At night they form a living ball of ants and wait for the next dawn. Leaf-cutter ants feed on fungi which they raise. The fungi are provided with pieces of leaves and a bed of decaying material upon which to grow.
13. Certain ants feed on a sugary substance secreted by aphids. The ants may care for the aphids by carrying them about and putting them on plants from which the aphids can obtain food.
14. Some ants enslave other ants. This may happen when a queen of one species invades the colonial home of another species, and takes over. The queen's offspring soon dominate the colony. Sometimes slave-making ants raid other colonies and capture workers that are then brought back to be slaves.
15. In the wagging dance, a bee indicates the direction of a food source by facing upward if the food is in a direct line with the sun or by facing downward if the food is in a line away from the sun. If the food is at an angle to the sun, the bee's body points at an angle also. The number of loops that the bee travels is related to the distance to the food; the more loops the bee makes, the closer the food is to the hive. If the food is within 100 yards of the hive, the bee performs a round dance, rather than a wagging dance.
16. The protozoans in the intestine of termites are able to digest wood fibers. As a result, the termites are able to get nourishment from wood. Termites cannot digest wood without the aid of the protozoans.
17. Certain fungi grow and form a sort of sheath around the roots of pine and oak trees. It is thought that the fungi act to absorb water and minerals from

the soil, which are then available for the tree. The fungi are believed to benefit by absorbing growth materials from the tree root.

18. Animals protect their territories by uttering warning cries and by attacking other animals that enter their territories.

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CHAPTER 11 Change and Decay

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Some simple organisms grow to full size and then divide to form two individuals, which in turn grow to full size. Other organisms pass through several stages in their life cycle—youth, maturity, and old age.	Growth and Life Cycles (p. 268)
2. Life Cycles of Animals	Insect life cycles are of two general types.	Things To Do #4 (p. 252)
A. The grasshopper life cycle	A young grasshopper is a nymph which looks like an adult, but has undeveloped wings and sex organs. By a process involving growth and the shedding of the external skeleton, the nymph gradually becomes an adult.	An Adult Insect (p. 243)
B. A moth life cycle	A moth passes through a series of life stages—egg, larva, pupa, adult. During the larval stage it feeds; as an adult, it reproduces.	Life Cycle of a Fruit Fly (p. 270)
C. Other animal life cycles	Life cycles among animals vary.	
3. Life Cycles of Plants	Some plants live longer than any of the animals.	
A. Annuals, biennials, and perennials	Plants that live a number of years are called perennials. Annuals live a single season, while biennials live two seasons.	
B. Plants and the soil	Natural processes tend to restore soil minerals. These processes include the breakdown of rock, and the decay of dead organisms. Soils may be mined by growing crops season after season, until certain minerals are exhausted. Wise use of the land prevents soil mining.	Things To Do, #5 (p. 252)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
4. Decay Processes	Without decay, the land would be covered and the sea would be filled with dead plant and animal remains.	A Decaying Log (p. 245)
A. The nature of decay	Bacteria and fungi are the main agents of decay. Decay products are added to soil, water, and air. Fertile soil is rich in humus.	Things To Do, #1 (p. 252)
B. Decay products and the topsoil	Some decay products make fine-grained soil more porous. It is important that topsoil should not be worn away. In areas where the soil is porous and rainfall is heavy, the most fertile soil sometimes is below the surface.	
5. The Nitrogen Cycle	In order to make proteins, plants need a nitrogen source.	
A. Nitrogen in air, soil, and water	Although the air is about 79 percent nitrogen gas, in this form the nitrogen cannot be used by plants. Plants can use nitrogen obtained from nitrates.	
B. The origin of nitrates	Nitrates are formed from air during electrical storms and by certain soil bacteria and algae. Nitrogen-fixing bacteria often form colonies in root nodules of plants belonging to the bean family.	Things To Do, #2 (p. 252)
C. How nitrates are used	Nitrates enter plants along with soil water. Animals obtain materials for making proteins by eating plants or other animals.	
D. Protein decay	Decay bacteria breakdown protein to form ammonia, while other bacteria use ammonia to make nitrates again. Another group of bacteria breaks ammonia	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	down into free nitrogen gas.	
E. A never-ending cycle	The movement of nitrogen from the air into nitrates, proteins, and ammonia and back to air again is called the nitrogen cycle.	Things To Do, #3 (p. 252)

RELATED FILMS

	Min.		
The Growth of Plants	21	B&W Color	EBF
Seed Germination	15	B&W Color	EBF
The Fish Embyro: From Fertilization to Hatching	12	B&W Color	EBF
Bacteria	19	B&W Color	EBF
Angiosperms: The Flowering Plants	21	B&W Color	EBF
The Importance of Microorganisms	28	Color	McGraw
An Animal Life Cycle	28	Color	McGraw
Microorganisms: Beneficial Activities	15	B&W Color	Indiana
Life Cycle of a Trout	10	B&W	UWF

OVERVIEW AND RATIONALE

In Chapter 11, certain changes that take place in the natural community are discussed. Some of these changes occur in individual plants and animals, as they grow, mature, and reproduce. Other changes involve physical factors and natural processes, such as those operating to break down rock and remove soil minerals. Still another group of changes concerns interactions between living and nonliving things. For example, bacteria and fungi produce changes in the bodies of dead organisms. The resulting decay products add to the fertility of the soil, and new generations of plants can complete their life cycles. Also, interactions take place between the gases of the atmosphere, certain groups of soil microorganisms, and higher plants and animals in the never-ending nitrogen cycle.

This chapter completes Block II. The group to follow deals with a specific organism, man, and the ways in which he influences his environment and, in turn, is influenced by it.

GETTING STARTED

As this chapter concerns change in the natural community, you might begin by asking students to list ways in which they change with time. This can lead to a discussion of growth and life cycles.

Students may be interested in finding out more about their individual growth patterns. Ask them to see if they can find listings of their weights and heights at various ages in such family records as baby books. Such data can be plotted on graph paper and will reveal interesting patterns. If such individual data are not available, there is information on page 270 that will serve as a substitute. After preparing the graphs, students may be interested to see if other organisms change in similar ways as they grow. An investigation of plant growth is explained on page 269 and one involving animal growth begins on page 269.

If the plant growth study is set up, it can serve as a point of reference throughout the study of Chapter 11. Various stages in the plant life cycles can be observed, and the plants can be discussed in terms of necessary soil minerals, interactions with the atmosphere, and the effects of microorganisms on plant growth.

CHAPTER NOTES

Life Cycles of Animals (page 239) Some students may be acquainted with the term *metamorphosis,* which refers to the structural changes that take place during the development of an organism. In the case of a grasshopper, the change is called a gradual or incomplete metamorphosis, while in the moth it is called complete metamorphosis. Roaches, crickets, lice, aphids and leaf hoppers have life cycles with a gradual metamorphosis. Fleas, wasps, ants, bees, beetles, flies, and butterflies have life cycles with complete metamorphosis.

Among the snakes that bear their young rather than lay eggs are the garter snakes, copperheads, and rattlesnakes. The familiar guppy is an example of a fish that gives birth to its young. This also is true of a variety of sharks. Aphids are insects that bear their young in some of their generations.

Life Cycles of Plants (page 244) It should be fairly easy to demonstrate the effect of mineral compounds on plant growth by adding some fertilizer to a section of grass. Leave a nearby section untreated to act as a control. Mark the areas with stakes and string so that they can be identified. Be sure to select sections of grass that will be in full sunlight, and keep them well watered throughout the demonstration. If grass is not available, you may want to perform a similar test using flats of grass seed sprouted in moist sand.

The Nitrogen Cycle (page 247) Students may be able to demonstrate the effect of nitrogen-fixing bacteria on the growth of clover plants. To do this, have them sterilize two flower pots full of soil. This treatment will, of course, kill any bacteria already present. Mix some powder containing nitrogen-fixing bacteria with the soil in one pot. This powder can be purchased from seed companies. Soak some clover seeds in water, and plant half of them in each of the pots. Keep the soil moist and put the pots in a well-lighted place. After the plants are well established, ask students to note any differences in the size and appearance of the plants. The students may be interested in weighing equal numbers of plants selected from the pots at random, in order to make their observations quantitative.

LABORATORY SUGGESTIONS

An adult Insect (page 243, one period)

In this exercise students will study the major structures of an adult grasshopper.

Materials: 24 grasshoppers, 24 hand lenses.

Preserved grasshoppers are available from biological supply houses, or students may want to capture live specimens. The observations suggested in the text can be made on live specimens kept in jars. Walking, feeding, and evidences of other life processes may be studied if live specimens are used.

Grasshoppers often will feed on leaves of the plants from which they are collected. Perhaps one or two specimens can be released outside so that flying motions can be observed also.

If preserved grasshoppers are used, have students wash them in tap water and blot them dry with a paper towel. The specimens can be placed on paper toweling or in dissecting trays for study. Students should have no difficulty locating the parts described in the text.

ANALYSIS QUESTIONS (page 243)

1. The hard, external skeleton provides a solid structure to which muscles can be attached.
2. Air, containing oxygen, can enter the grasshopper's body through the openings along the side of its abdomen. These openings connect with tiny air

tubes that branch and lead to various body tissues.

3. The wings are moved by heavy muscles attached to the external skeleton. The wings are attached externally to the thorax. Without dissecting the grasshopper it would be impossible to see these muscles and tissues.

A Decaying Log (page 245, one period)

This exercise provides an opportunity for students to observe the effects produced by decay microorganisms.

Materials: decayed log or pieces of decaying wood, 24 hand lenses.

If possible, take the class into a wooded area to observe evidences of decay microorganisms at work. Or have students bring small samples of decaying wood to class. Almost any piece of wood that has been partially buried in moist soil for a time will be interesting to study.

If samples of decaying wood are not available, have students bury various types of materials in flower pots filled with moist soil. Paper, cardboard, cloth, and pieces of soft wood can be used. Keep the soil moist and check the samples every few days for evidence of decay.

ANALYSIS QUESTIONS (page 246)

1. Microorganisms such as bacteria are most important in producing decay.
2. Answers will vary. Saprophytes are organisms, such as molds and mushrooms, that obtain their food supplies by decaying dead materials.
3. Given enough time, the materials of a decaying log will be converted into soil materials and atmospheric gases, such as carbon dioxide and water vapor.

WORD MEANINGS (page 249)

1. chitin—material that makes up the external skeleton of an insect.
2. decay—the breakdown of dead plants and animals.
3. erosion—process by which soil is worn away.
4. maturity—reproductive period of life.
5. nitrogen—substance that makes up 79 percent of the air.
6. nitrogen-fixing bacteria – organisms that can make nitrates from elements in air.
7. nodule—a fleshy swelling that contains bacteria, and is found on a root.
8. nymph—a stage in the life cycle of a grasshopper that does not occur in the life cycle of a moth.
9. saprophyte—any plant that obtains energy from the bodies of dead organisms.
10. thorax—part of an insect body to which the legs are attached.

1. A life cycle is best defined as *(d) the stages an organism passes through in each generation.*
2. A moth larva is *(a) a wormlike organism.*
3. Humus *(b) is the remains of plants and animals in soil.*
4. A carbohydrate *(b) contains carbon, hydrogen, and oxygen.*
5. Nitrates *(c) contain nitrogen in a form available to plants.*
6. Which of the following kinds of organisms are affected by the nitrogen cycle? *(d) all of these.*
7. A biennial is *(c) a plant that produces its seeds during the second growing season and then dies.*

SELF TEST (page 250)

1. True
2. False. The period of a life cycle in which growth takes place is called youth.
3. False. Female grasshoppers usually lay their eggs in the soil.
4. True
5. False. The stages in the life cycle of a moth are: egg, larva, pupa, adult.
6. True
7. False. An insect has an external skeleton, while the skeleton in the human body is internal.
8. False. Insect wings are attached to the thorax.

9. False. Most trees are perennials.
10. True
11. False. Corn grows best in fertile soil.
12. True
13. True
14. False. If decay did not take place, the earth would soon be covered with dead plants and animals.
15. True
16. False. Most of the air is composed of the element nitrogen.
17. True
18. False. Nitrogen-fixing bacteria can combine free nitrogen with other elements to produce nitrates.
19. True
20. True
21. True
22. False. Soil bacteria should be thought of as generally helpful to life.
23. True

DISCUSSION QUESTIONS (page 251)

1. Some organisms, like paramecium, grow to full size and then divide to form two new organisms. Such forms do not grow old and die in the manner of higher forms.
2. Both a moth and a grasshopper begin their life cycles as fertilized eggs, from which young insects develop and hatch. In time, each passes through certain stages as it matures. The adults may reproduce and eventually die. However, in the case of grasshoppers, the young have the same general form as the adult, while in the moth, the young are not at all like the adult.
3. The human body begins life as a fertilized egg. After a number of months, during which development takes place, the young is born. Following a period of growth, the young matures into the adult form. The adult may reproduce, and after a while enters a period of old age. Eventually, death ends the life cycle.
4. An external skeleton provides an insect with a strong protective covering. In an animal of small size, it provides effective places of attachment for body muscles.
5. The thorax is the body part just behind the head. The legs and wings are attached to the thorax. The abdomen is the hind section of an insect's body, just back of the thorax.
6. In order to decide whether a plant is an annual, a biennial, or a perennial, you would have to know about its life cycle. Annuals complete their life cycles in one season, while biennials live for two seasons. Perennials, on the other hand, live for a number of years.
7. Minerals are removed from topsoil by plants that have their roots in the soil, by being dissolved and carried away by ground water, and by being blown away by wind.
8. Soil minerals can be restored by the breakdown of rocks, the decay of plant and animal bodies, and the rotation of crops. Sometimes it is necessary to add required minerals to soil in the form of fertilizers.
9. Animals obtain their mineral needs by eating plants that have taken in minerals from the soil, or by eating animals that have eaten plants.
10. Decay is the process whereby numerous microorganisms break down the bodies of dead plants and animals, as they use such dead material for food.
11. Decay is a desirable process in that it aids in the return of materials trapped in dead bodies to the soil and atmosphere. It may be considered harmful when it involves things that man desires to keep, such as stored food supplies, housing materials, or clothing.
12. Topsoil is formed as rock is broken down into small pieces, as certain rock materials are changed chemically into clay, and as decay products are mixed with these particles.
13. The most fertile soil may be several feet below the surface in areas where water from heavy rainfall soaks through the soil carrying minerals and decay products with it. This process is called leaching.

14. Nitrates are important soil minerals because they are the compounds that most plants use as their nitrogen source.
15. The nitrogen cycle is a series of events during which soil nitrates are formed from nitrogen gas, used by plants to produce proteins, taken in by animals that eat plants, released to the soil as wastes and decay products, and finally returned to the air by the action of certain bacteria that break down nitrogen containing compounds.
16. In the nitrogen cycle, certain bacteria are able to produce nitrates from the nitrogen of the air by combining it with other elements. Other bacteria break down waste materials and the bodies of dead plants and animals, which releases nitrogen containing compounds into the soil. Certain other bacteria break down the nitrogen containing compounds, which releases nitrogen back into the air.
17. Members of the bean family are of particular importance in crop rotation programs because they support colonies of nitrogen-fixing bacteria in their root nodules. Thus, by growing crops of beans from time to time, nitrates can be built up in the soil.
18. Animals depend on plants for nitrogen containing compounds from which animal proteins are built. Animals also depend on plants for a supply of energy containing carbohydrates and plant oils, which plants produce by photosynthesis.

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BLOCK II Laboratory Investigations

THE CHAPTER AT A GLANCE

INVESTIGATION	PURPOSE	RELATED CHAPTERS
Part I: Aquariums and Terrariums as Sample Communities		
1. Setting Up a Freshwater Aquarium (p. 254)	To establish a small freshwater laboratory community	Chapter 6
2. Other Types of Aquariums (p. 256)	To establish a balanced aquarium	Chapter 6
3. A Bog Terrarium (p. 256)	To establish a bog community in the classroom	Chapter 6
4. A Woodland Terrarium (p. 257)	To establish a woodland community	Chapter 6
5. A Desert Terrarium (p. 257)	To establish a desert community	Chapter 6
Part II: Demonstrations and Investigations		
1. The Rate of Photosynthesis (p. 258)		
A. Light and photosynthesis	To demonstrate the relationship between light intensity and the number of bubbles released from an **Elodea** stem	Chapter 6
B. Carbon dioxide and photosynthesis	To test the effect of increased carbon dioxide concentration on bubble production by an **Elodea** stem	Chapter 6
C. Color of light and photosynthesis	To test the effect of different colors of light on bubble production by an **Elodea** stem	Chapter 6
2. Loss of Water by Plants (p. 260)		
A. A transpiration demonstration (p. 260)	To demonstrate that water is lost from the shoot system of a potted plant	Chapter 6
3. Higher Plants (p. 261)		
A. Types of higher plants (p. 261)	To compare the structure of ferns, cone-bearing plants, and flowering plants	Chapters 6, 7
B. Investigating a factor in plant growth (p. 261)	To test the effect of soil depth on seed sprouting	Chapter 8

INVESTIGATION	PURPOSE	RELATED CHAPTERS
C. Plant foods for man (p. 261)	To survey the kinds of plant foods used by man	Chapter 7
4. Population Changes (p. 262)		
A. Changes in a laboratory community (p. 262)	To investigate changes in the microorganism populations of a small laboratory community	Chapter 7
5. Soils and Water (p. 263)		
A. Water absorption and retention (p. 263)	To measure the amount of water that can be absorbed by dry soil samples and to measure the amount of time that this water can be held by the samples	Chapter 8
B. Acid and alkaline soils (p. 264)	To determine if a soil sample is acid or alkaline	Chapter 8
6. Root Growth and Structure (p. 264)		
A. Seeds in a pocket garden (p. 264)	To demonstrate that seedling roots are influenced by gravity	Chapter 9
B. Roots and water (p. 265)	To demonstrate that seedling roots are influenced by water	Chapter 9
C. Types of roots (p. 265)	To compare the root structures of various types of plants	Chapter 9
7. Adaptations (p. 266)		
A. Adaptations of a starfish (p. 266)	To examine the structure of a starfish	Chapter 9
B. Adaptations of a fish (p. 267)	To observe the structure and behavior of a fish	Chapter 9
8. Growth and Life Cycles (p. 268)		
A. Investigating growth in plants (p. 269)	To study the growth rate and growth pattern of seedlings	Chapter 11
B. Investigating growth in animals (p. 269)	To study the growth rate and growth pattern of an animal	Chapter 11
C. Growth of the human body (p. 270)	To demonstrate that the growth pattern of humans is similar to that of other organisms	Chapter 11
D. Life cycle of a fruit fly (p. 270)	To observe and study the stages in the life cycle of an insect	Chapter 11

INVESTIGATION	PURPOSE	RELATED CHAPTERS
Part III: Investigating a Land Community		
1. Introduction (p. 271)	To select an area for study	Chapter 6
2. Mapping the Area (p. 271)	To prepare a map of the area and indicate its obvious features	Chapter 6
3. Studying Physical Factors of the Area (p. 271)	To investigate the physical factors of the area, such as temperature, relative humidity, various soil factors, light intensity, and air movements	Chapters 8, 11
4. Comparing Land and Water Environments (p. 274)	To study the similarities and differences between a land and an aquatic evironment	Chapter 8
5. Studying Habitats (p. 275)	To survey the habitats that occur in a land community	Chapter 8
6. Surveying the Plants in a Land Community (p. 275)	To study and collect plant specimens	Chapters 6, 7
A. Weed density (p. 277)	To determine the number of weed plants that are growing in a sample of the area	Chapter 6
7. Surveying the Animals of a Land Community (p. 277)	To study and collect animal specimens	Chapter 7
8. Common Pests (p. 278)	To survey an area for the presence of common pests	Chapters 7, 9
9. Studying Soil Organisms (p. 278)	To determine what organisms are present in a soil sample	Chapters 7, 9
10. Investigating Interactions Among Organisms (p. 279)	To observe examples of positive and negative interactions within a land community	Chapters 9, 10, 11

RELATED FILMS

	Min.		
Experiments in Photosynthesis	20	B&W Color	EBF
The Community	11	B&W Color	EBF
The Temperate Deciduous Forest	17	B&W Color	EBF
The Grasslands	17	B&W Color	EBF
The Desert	22	B&W Color	EBF
Seed Germination	15	B&W Color	EBF
Diversities and Similarities of Plants	28	Color	McGraw
Roots	28	Color	McGraw
Population Ecology	28	Color	McGraw
The Deciduous Forest	28	Color	McGraw
Grasslands and the Desert	28	Color	McGraw

OVERVIEW AND RATIONALE

This section provides a collection of investigations that can be used to supplement the chapters in Block II. There are three parts. *Part I* explains how to establish various kinds of laboratory communities including a freshwater aquarium, a bog terrarium, a woodland terrarium, and a desert terrarium. *Part II* presents a number of experiments and demonstrations that are related to specific topics in Block II. *Part III* provides detailed instructions for a study of a land community. This latter study is made up of a series of sequential investigations that can be used as a group of field and laboratory experiences that will occupy a number of class periods. It can also serve to summarize many of the major concepts presented in Block II, such as the concept of food groups, interactions of organisms within a natural community, adaptations of organisms to their environments, decay processes, and the nitrogen cycle.

LABORATORY SUGGESTIONS

Part I: Aquariums and Terrariums as Sample Communities

Setting Up a Freshwater Aquarium (page 254, one period)

Materials: aquarium with cover, sand, gravel, small stones, aquatic plants, aquatic animals such as a snail, a clam, a crayfish, a tadpole, a small fish.

Be sure to have the students wash the aquarium with soap and water, and rinse it several times before using it. If possible, fill the aquarium with clear pond water. If tap water is used, be sure to let it stand in an open container for at least 24 hours before adding it to the aquarium. Pour the water onto a piece of paper in the aquarium. This will prevent a stirring up of the sand and gravel.

Plant only a few plants of different species. This will leave room for them to grow. After a few days, if any of the plants seem to be dying, remove them before they begin to decay. Also, after the plants begin growing, it may be necessary to thin them out in order to prevent overcrowding.

ANALYSIS QUESTIONS (page 255)

1. It is probable that microorganisms exist in the aquarium. This could be checked by direct observation, using a microscope. Some of these organisms were, no doubt, present in the water used to fill the aquarium. Others may have been introduced when the plants and animals were added. Still others may have come in on dust particles in the form of cysts or spores.
2. Good light favors the growth and increase of algae because these plants are chlorophyll-bearing and manufacture food in the presence of light.
3. If a fish in an aquarium gulps air at the surface, this suggests that the oxygen content of the water is too low. Depending on the situation, this problem may

be corrected by reducing the number of animals in the aquarium, increasing the number of green plants, or adding an aerator and pump.

Other Types of Aquariums (page 256, one period)

Materials: battery jar or stainless. steel aquarium, sea water, aerator and pump, seaweed, marine animals such as a clam, sea anemone, starfish, or small fish.

A saltwater aquarium can be established in much the same manner as a freshwater aquarium, however, the use of saltwater presents certain special problems. For example, saltwater causes corrosion of metal parts. For this reason, either an all glass battery jar or a stainless steel aquarium should be used. Special non-corrosive saltwater aquariums can be purchased from biological supply houses.

If sea water is not available, a synthetic form can be made with salts purchased from a supply house. Marine plants and animals also can be purchased from such a source. An aerator and pump will be needed to supply oxygen to the water, and it is important to keep a saltwater aquarium cool. Place it where it will receive little or no direct sunlight.

Once again, it is important to prevent overcrowding. Limit the animals to a few small forms. You might include a clam, a sea anemone on a rock, a small fish, and a bit of seaweed. To feed the animals, place them in separate containers of sea water and provide them with bits of meat, such as clam. This procedure takes time and effort, but it will prevent fouling of the water in the aquarium.

A Bog Terranium (page 256, one period)

Materials: aquarium with cover, sand, bog soil, culture bowl, liverworts, mosses, carnivorous plants, such as pitcher plants, sundews or Venus's flytraps, ferns, club mosses, a small turtle, frog, and salamander.

If bog soil is not available, use a mixture of 3 parts loam, one part sand, and one part peat moss. When transplanting the ferns and carnivorous plants, be sure to also move some of the soil in which they were growing. Try not to disturb the roots.

This terrarium must be kept covered in order to provide a proper humidity for the bog organisms. Keep the terrarium cool and in a medium amount of light. Frogs, salamanders, and carnivorous plants can be fed by releasing some fruit flies into the terrarium from time to time. Frogs and salamanders will also eat mealworms which you can raise in the laboratory.

ANALYSIS QUESTIONS (page 257)

1. Liverworts must be grown in wet soil since this provides the habitat to which they are adapted. They are non-vascular plants, lack roots, and absorb water through their short rhizoids. Liverworts and mosses represent a transition between aquatic algae and higher land plants.
2. Algae are commonly found in soil and would be expected to be present in the very moist soil of a bog terrarium. They may grow on the inner surface of the terrarium because it is a warm, moist, well-lighted place, and as such, it provides a suitable environment for these plants.
3. Young bean plants would not be expected to grow well in a bog environment. Bean plants are adapted to grow in much drier soil and in air of lower humidity. Also, bog soil generally is quite acid and low in nitrate content.

A Woodland Terrarium (page 257, one period)

Materials: aquarium with cover, sand, forest soil, ferns, mosses, club mosses, small forest plants, piece of decaying log, lichens on rock, small toad, salamander.

The woodland terrarium should be drier than the bog terrarium. Although the soil should be moist, it should not look wet or "muddy." As before, prevent overcrowding and keep the terrarium in a cool place. Cover it to slow down evaporation of water and put it where it will receive medium light. Toads and salamanders usually will feed on mealworms.

The Desert Terrarium (page 257, one period)

Materials: aquarium, gravel, sand, small desert plants, small desert animals such as lizards.

The desert terrarium should be drier than the woodland terrarium. No glass cover is needed on the aquarium; instead, use a fine screen or netting cover to prevent the escape of the animals. Keep the terrarium in a well-lighted place. Most lizards will feed on mealworms.

Part II: Demonstrations and Investigations

The Rate of Photosynthesis (page 258)

This is a series of three experiments that makes use of a single technique to measure the rate of photosynthesis in an *Elodea* stem.

Light and Photosynthesis (page 258, 2 periods)

Materials: 24 *Elodea* stems, 12 single-edged razor blades, metal foil, 12 thermometers, 24 test tubes, 24 pint jars, pond water, ice, 12 laboratory lamps, 12 rulers.

Have the students work in pairs. This will reduce the amount of equipment needed and will simplify the technique. In each pair, one student can set up and maintain the test plant, while the other student works with the plant kept in dim light.

Bubbles will appear at the cut end of the *Elodea* stem. Have the students keep the pond water at room temperature. Heat from the lamp will tend to increase the temperature of the water, but this can be corrected by changing the water from time to time or by adding and removing a piece of ice.

It is best to use *Elodea* that has been growing in a well-lighted place, otherwise bubbles may not appear until the stem has been in light for a time. Have the students wait until the bubbles seem to be appearing at an even rate before beginning the counts.

Interested students may want to graph the data. Have them use the average number of bubbles produced per minute as the units of the vertical axis, and the distance to the light in feet as the units of the horizontal axis.

ANALYSIS QUESTIONS (page 259)

1. Answers will vary. Generally, as the light intensity increases, the rate of photosynthesis will also increase. In very bright light however, further increase in the light intensity may not result in an increase in the rate of photosynthesis.
2. If the temperature was changed as the light intensity was changed, the observer could not tell whether the results were due to the temperature or to the light, or to the two factors operating together.
3. The second tube of *Elodea* serves as a control in this experiment.

Carbon Dioxide and Photosynthesis (page 259, one period)

Materials: 24 *Elodea* stems, 12 single-edged razor blades, metal foil, 24 test tubes, 24 pint jars, pond water, 12 thermometers, ice, straws, 6 Bunsen burners, 6 large beakers, 6 ring stands.

Students probably will need some help in planning this experiment. You may want to discuss it with the class and have the group plan a procedure. One way to test the effect of carbon dioxide on the rate of photosynthesis in *Elodea* would be to do the following:

a) Boil the pond water in a beaker in order to drive off dissolved gases. Let the water cool.

b) Set up two test tubes with pond water and *Elodea* stems as described in the previous experiment on page 258. One tube will serve as a control and this tube will contain very little carbon dioxide.

c) Add carbon dioxide to the second tube by blowing breath into the water through a straw or by adding some 0.5%

sodium bicarbonate solution to the water.

d) Put both tubes in bright light and determine the average number of bubbles per minute produced from the *Elodea* stem in each. Control the temperature in each case as described in the previous experiment.

While discussing this experiment, you may want to demonstrate the presence of carbon dioxide in exhaled air. This can be done by bubbling the breath through a sample of limewater in a test tube. A milky precipitate is produced when carbon dioxide reacts with limewater. To prepare limewater, add an excess of calcium hydroxide to some distilled water. Shake the mixture and let it stand for at least 24 hours. Pour off the clear liquid and use this liquid in the test.

ANALYSIS QUESTIONS (page 259)

1. The tube without carbon dioxide in the water served as a control.
2. An increase in the concentration of carbon dioxide in the water results in an increase in the rate of photosynthesis in an *Elodea* stem.
3. It is important to keep the light and temperature conditions the same in each tube so that there is a single difference between the test and the control tube. Otherwise, it would not be possible to conclude which factor was responsible for the differences in the results.

Color of Light and Photosynthesis (page 259, 2 periods)

Materials: 24 *Elodea* stems, 12 single-edged razor blades, metal foil, 24 test tubes, 24 pint jars, pond water, 12 thermometers, ice, cellophane—clear, red, green, and blue.

You may want to demonstrate that white light from the sun is made up of colors. To do this, cause a beam of light to pass through a prism. By moving the prism about, you can determine how to hold it so that the spectrum of colors is cast on a wall or the ceiling. Have the students note that white light contains components that are red, orange, yellow, green, blue, and violet. Each component consists of light energy of a different wave length. A rainbow is due to sunlight passing through droplets of water in the air that act as prisms. A small group of students might be assigned the task of gathering more information about the nature of light and reporting their findings to the class.

It has been determined that violet and red wave lengths generally are more effective sources of energy for photosynthesis than the other wave lengths. However, students may have difficulty confirming this by using the cellophane technique. It is likely that each of the cellophane samples will allow more than one wave-length of light to pass through. Also, some cellophane may have a deeper color than the other samples. It may be necessary to use more than one thickness of green, for example, to produce a light intensity similar to that produced by one thickness of blue.

Ask students to identify other "sources of errors" in the procedure.

ANALYSIS QUESTIONS (page 260)

1. Answers will vary. Generally, green light is the least effective as a source of energy for photosynthesis.
2. A light meter might be used to determine when the amount of light coming through two samples of cellophane is equal.

Loss of Water by Plants (page 260)

A Transpiration Demonstration (page 260, one period)

Materials: potted plant, plastic bag, string, glass plate, bell jar, vaseline.

This demonstration might be set up by a small group of students a few days before a class discussion of stomata. You might withhold any comment on the demonstration until the students have had a chance to observe the results. Then you might ask them for their explanations. They probably will reason that the water collecting on the inside of the bell jar must be coming from the plant's leaves and stems, and that there must be openings in these plant parts through which the water can escape.

ANALYSIS QUESTIONS (page 260)

1. The plant obtains water lost in transpiration, through its roots from the soil in the flower pot.
2. The flower pot and its soil was enclosed in a plastic bag to demonstrate that the water collecting on the inside of the bell jar comes from the plant's leaves and stems, rather than from the soil.
3. A plant that loses water rapidly from its leaves and stems would not be able to survive in a dry place. Desert plants, on the other hand, generally have low rates of transpiration and can conserve water in their tissues.

Higher Plants (page 261)

Types of Higher Plants (page 261, one period)

Materials: a variety of plant samples including ferns, cone-bearing plants, and flowering plants.

This activity should help students to distinguish between the three major groups of vascular plants. They should note that ferns have leaves that are large, typically divided into leaflets, and grow from underground stems. Ferns do not produce flowers or seeds, but they may form spores on the undersides of their leaves. The cone-bearing plants often have evergreen, needlelike leaves. They produce seeds that are freely exposed in cones. The flowering plants usually have flat leaves. They produce seeds that have seed cases and develop in an enclosed ovary. The ovary ripens to form the fruit of the flowering plant.

ANALYSIS QUESTIONS (page 261)

1. These organisms are called plants because they are chlorophyll-bearing, are unable to move about from place to place, and have stiff tissues that are composed of cells with cell walls.
2. These plants differ from algae, molds, and mosses, in that they are larger and more complex in their structure, and they possess vascular tissues which are not found in lower plants.
3. These plants are called vascular plants because they possess vascular or conducting tissues.

Investigating a Factor in Plant Growth (page 261, one period)

Materials: 6 large, deep flower pots, loam, bean or pea seeds.

This demonstration can be set up by a small group of students. Then the results can be observed and discussed by the class. Other kinds of seeds might be used, but very small seeds should be avoided, because the seedlings that result might not be able to push through more than an inch or so of soil.

Students will note a relationship between the depth of planting and the time that it takes for the seedlings to appear. Also, depending on the kind of seeds used, seedlings may not appear at all in the case of the deeper plantings.

ANALYSIS QUESTIONS (page 261)

1. Answers will vary. Generally, the deeper the planting, the longer it takes for the seedlings to appear.
2. More than one seed was planted to increase the probability that some seeds would sprout. There is always the chance that a single seed selected will not sprout because it is not viable or has been damaged by some chance factor.
3. Other kinds of seeds and seedlings probably would be affected in a similar way. This idea could be confirmed by performing the same test using other kinds of seeds.

Plant Foods for Man (page 261, one period)

Materials: a variety of food samples.

Students can accomplish this activity

by visiting a local market or grocery store, and by making notes of their observations. Or, you may want to have individuals bring various food samples to class for group study.

Most plant foods are from flowering plants and can be classified as parts of roots, stems, leaves, flowers, fruits, seeds, or a combination of these parts. However, students probably will need some help getting started. You may want to provide them with a few examples.

Roots: sweet potato, carrot, radish, beet, turnip, rutabaga.
Stems: asparagus, Irish or white potato, yam.
Leaves: cabbage, brussel sprouts, lettuce, spinach.
Flowers: cauliflower, broccoli, artichoke.
Fruits: apple, pear, peach, plum, apricot, grape, string bean, melon, banana, avocado, grapefruit, olive.
Seeds: pea, bean, peanut, coconut, walnut, almond.

ANALYSIS QUESTIONS (page 262)

1. Answers will vary. Fruits and seeds probably will be listed most frequently.
2. The fruit usually consists of a ripened ovary which is greatly enlarged and contains the seeds.
3. Generally, the fruits in the market are plant fruits. The vegetables usually consist of other plant parts such as roots, stems, and leaves, but a number of fruits also may be included. For example, string beans, squash, and tomatoes are plant fruits.
4. Answers will vary.

Population Changes (page 262)

Changes in a Laboratory Community (page 262, five periods)

Materials: 24 small jars, pond water, large beaker, Bunsen burner, ring stand, dried peas or beans, mixed culture of microorganisms, 24 medicine droppers, 24 microscopes, 24 slides, 24 cover glasses.

The jars may be plugged with cotton to reduce evaporation, but they should not be sealed. Students should be cautioned not to add more than one or two dried seeds to a 50 ml culture. If the culture water becomes very cloudy with decay bacteria, it probably means too many seeds have been added, and it may be necessary to start again.

Have students check their cultures each day for the first few days so that they can become acquainted with the organisms present and the technique of sampling and counting. After they have developed some technique skills, the students should check the cultures every other day. It will be interesting to continue this study for at least two weeks or until only a few microorganisms seem to be left.

ANALYSIS QUESTIONS (page 263)

1. Answers will vary. Generally, as the population of larger forms increases, the population of smaller forms tends to decrease.
2. Larger organisms usually are more common near the end of the study, because they feed on the smaller forms.
3. The seeds were added as a source of food for decay organisms, which in turn supplied food for other organisms.
4. Answers will vary. If larger organisms increase in number as smaller ones decrease in number, this result would be evidence of a food chain operating in the culture.

Soils and Water (page 263)

Water Absorption and Water Retention (page 263, one period)

Materials: 3 widemouth bottles, gravel, sand, loam, graduated cylinder.

You may want to have a small group of students set up this demonstration for the class. The bottles can be left on a shelf and observed by the students from time to time. It probably will take several days for the soil samples to become dry. Students should note that the coarser particles absorb the smaller amounts of water and also that these particles dry out more quickly than the others.

ANALYSIS QUESTIONS (page 264)

1. The loam absorbed the most water and the gravel absorbed the least. Water cannot move easily into the spaces occupied by the large, nonporous gravel particles, whereas water can move readily into space occupied by the many tiny particles of loam.
2. The gravel dries out first, and the loam dries out last.
3. Clay is made up of finer grained particles than loam. Therefore, the clay should absorb more water and dry out more slowly than the loam.

Acid and Alkaline Soils (page 264, one period)

Materials: bog soil, breaker, limewater pipette, phenophthalein solution.

This demonstration might be performed for the class by a small group of students. The students may need help in understanding the basic ideas involved, and the teacher might do the following beforehand:

a) Show the students that phenolphthalein solution produces a pink color when added to a test tube half filled with limewater.

b) Show them that phenolphthalein solution is colorless in a test tube of dilute hydrochloric acid.

c) Add hydrochloric acid one drop at a time to the pink limewater from step *a,* and have the students observe that after a certain amount of acid has been added, the pink color disappears. This is because phenophthalein is only pink in an alkaline condition. When the acid neutralized the alkaline limewater, the pink color disappeared.

Students should understand that when the bog soil caused the pink color to disappear from the water sample, it did so because it neutralized the alkaline limewater. Thus, the soil is acid. Some students may be interested in checking the acid-alkaline condition of soil samples from their home gardens using the same technique.

ANALYSIS QUESTIONS (page 264)

1. The filtered liquid was colorless. This indicates that the soil was acid since it neutralized the alkaline limewater.
2. Lime may be added to soil to neutralize its acid content.
3. Pitcher plants are adapted to live on acid soils.

Root Growth and Structure (page 264)

Seeds in a Pocket Garden (page 264, one period)

Materials: radish seeds, 2 glass plates (4 inches by 4 inches), white blotting paper, rubber bands, shallow dish.

This demonstration can be set up for the class by a small group of students. Other kinds of seeds might be used, but they should be small. Otherwise they cannot be sandwiched easily between the glass plates. The important thing is to keep the blotter in the glass sandwich moist at all times. Some students may note that as far as the seeds are concerned, the direction of the earth's gravity and the direction of the water source are the same. Therefore, it will not be possible to determine whether the roots are growing toward gravity or toward water.

ANALYSIS QUESTIONS (page 265)

1. Regardless of the position of the glass sandwich, the roots grow down toward the earth's gravity. This result suggests that gravity influences the direction of root growth, but does not prove it.
2. In this demonstration, the earth's gravity and the source of water are in the same direction from the seeds. Therefore, it is difficult to determine whether the root growth was influenced by the earth's gravity, by the water source, by both, or by some other factor or factors.

Roots and Water (page 265, one period)

Materials: radish seeds, 2 glass plates (4 inches by 4 inches), white blotting paper, tape.

This demonstration can be set up for the class by a few students. The important thing is to have the soaked seeds between two distinctly different moisture conditions. Wide masking tape can be used to seal the glass plates together. Gravity should not be an important factor in this test, so lay the glass sandwich on a flat surface.

Students may want to repeat this demonstration in a modified form to see if the influence of water or gravity is the stronger. To do this, they might keep the glass plate standing upright with the moist blotter at the top.

ANALYSIS QUESTIONS (page 265)

1. Root growth is influenced by the presence of water. The fact that the roots grow toward the moist blotter is evidence of this.
2. If the glass sandwich was placed upright so that the wet blotter was on top, this demonstration could be used to see if water or gravity is a stronger influence on root growth.

Types of Roots (page 265, one period)

Materials: a variety of roots from seed plants, 24 hand lenses.

You may want to have students bring samples of roots to class for group observations. Ask them to locate as many different kinds as possible. They should be able to find examples of fibrous roots such as a grass plant produces, thick fleshy roots as represented by a carrot, woody roots from trees, aerial roots such as those that anchor Virginia creeper plants to walls, and prop roots that arise from the stems of such plants as corn and give the plant added support.

ANALYSIS QUESTIONS (page 266)

1. Root systems are similar in that they are underground structures adapted to absorb water and anchor plants. They differ in form. Some are fibrous, while others are fleshy or woody. Some are adapted to store food, or to support the plant above the ground, as in the case of corn prop roots.
2. Roots often penetrate many feet into the soil. Thus, many plants survive in areas where the top few inches of soil is dry.
3. Thick, fleshy roots, such as a carrot or sweet potato, store quantities of plant foods.

Adaptations (page 266)

Adaptations of a Starfish (page 266, one period)

Materials: 12 starfish, 12 scalpels, 12 dissecting pans, 24 hand lenses.

Be sure to have the students wash the preserved starfish thoroughly in tap water before beginning their observations. Students should have no difficulty locating the parts described in the text. Hand lenses will be helpful for observing such small parts as the tube feet. Also, have students look at the spines that cover the upper surface of the animal's body. They will also be able to see the tiny jawlike pedicellariae that prevent debris and other organisms from collecting on the starfish's body.

ANALYSIS QUESTIONS (page 267)

1. The spines of starfish and their relatives help to protect them against predators. The tiny jawlike pedicellariae on the upper surface of the body open and close like pincers and keep other organisms from attaching to the surface.
2. Because it can thrust its stomach out of its mouth, a starfish is able to digest the body of a clam or oyster, while that animal is still in its shell.
3. The digestive glands of the starfish are of particular importance because digestive fluids and enzymes must be produced in sufficient quantity to digest the body of a clam while the clam is still in its shell. Thus, pieces of the clam's

body are digested away, rather than being removed by a biting action.

Adaptations of a Fish (page 267, one period)

Materials: 12 live fish, 12 containers of pond water, 12 flashflights.

Guppies, mosquito fish, or goldfish can be used in this activity. Have students note that the greatest force for swimming comes from the tail as it moves from side to side. Ask them to see if they can observe the functions of the other fins. Some students may be interested in measuring the rate at which the fish takes gulps of water. Ask them if they can determine whether or not this rate is related to the activity of the fish. Ask them what other factors might affect the rate of gulping.

ANALYSIS QUESTIONS (page 268)

1. A fish is well adapted to life in the water by its streamlined shape, the presence of fins for moving through the water, and the presence of gills for obtaining oxygen from water.
2. Fish obtain oxygen from the water through their gills. As water passes over the gills, dissolved oxygen diffuses through the membranes covering the gills and enters the blood stream.
3. Answers will vary.

Growth and Life Cycles (page 268)

The first part of this section consists of three related investigations, as follows:

a) A study of the growth pattern in a plant.
b) A study of the growth pattern in an animal.
c) Data for comparing the growth pattern of a group of humans with that of the plants and the other animal.

Investigating Growth in Plants (page 269, one period to set up)

Materials: pea or bean seeds, two flats of loam, sand, fertilizer, ruler, graph paper.

If several flats are available and you have space, you may want to divide the students into groups of two or three and have each group set up an experiment. Otherwise, have a small group set up one experiment for the class. Students can take turns making the necessary measurements and reporting to the class.

To determine how much fertilizer should be used in flat A, follow the directions on the package. Almost any general purpose commercial fertilizer can be employed.

Caution students to measure from the base of the plant to the same point of the growing tip each time. This may become a problem, particularly if different students are doing the measuring from time to time.

ANALYSIS QUESTIONS (page 269)

1. Answers will vary. Generally, plant growth rates will be slow early in the study, then they will increase to a maximum rate, and finally they will decrease as the plants approach maturity.
2. Answers will vary. Since the soil conditions in flat A are more favorable for plant growth than those in flat B, it is expected that the growth rate will be more rapid in flat A.
3. Answers will vary. It is expected that individual differences will be noted in growth rates. These differences may be due to natural variations that exist among the plants.

Investigating Growth in Animals (page 269)

Materials: young animals, rulers, balances, containers for animals, food for animals, graph paper.

It might be well to begin this study early in the year so that data is available when it is needed. If animals are kept in the classroom, small groups of students can be assigned the task of keeping records of the animals' lengths and weights. Measurements can be made once every few days. If only a few animals are studied, small groups of students can take turns making the measurements. Or, if a number of young fish, such as guppies, or young tadpoles are available, you might want each student to keep records of the measurements on an individual specimen. Each student might establish a miniature aquarium using a small jar of pond water with bits of green aquatic plants added to supply food and oxygen for the animal. Supplemental food can be added from time to time.

Some students may have young pets at home that can be measured. It will be more interesting if data from a number of different kinds of organisms can be collected and shared.

ANALYSIS QUESTIONS (page 270)

1. Answers will vary. Generally, the young animal's growth rate will be slow at first, but soon will increase to a maximum, and then slow down as the animal approaches maturity.
2. The growth rate patterns in plants and animals are very similar. In each case, the growth rate begins slowly, increases to a maximum and then decreases.
3. If several animals of the same age and species were used, the growth rate measurements could be averaged. The averages would be more representative of the group than the measurements from any one organism in that group.

Growth of the Human Body (page 270, one period)

Materials: graph paper.

If any students have data from family records on their own growth in height or weight, encourage them to plot these data in addition to those provided in the text. Data concerning growth rates in brothers and sisters might also be used. If such individual data are available in quantity, the students might want to average them, and compare the averages with the text data.

The early slow growth rate that occurs in the human is not evident in these graphs because it takes place before birth.

ANALYSIS QUESTIONS (page 270)

1. The growth rate pattern of these boys is similar to the middle and later phases of growth in the other organisms that were studied. That is, the rate increases and then decreases.
2. The graphs of human heights and weights are similar in that the lines generally follow the same paths.
3. The graph lines produced by plotting the data for each of the organisms studied are generally "S" shaped. Only the upper part of the "S" appears in the human growth graphs, since the slow rate of growth occurs before birth.

Life Cycle of a Fruit Fly (page 270, one period to set up)

Materials: fruit flies, agar, bunsen burner, ring stand, can, overripe bananas, 24 slides, 24 widemouth bottles, paper towel, cotton, 24 microscopes, 24 hand lenses, refrigerator.

When preparing the agar-banana medium, it is a good idea to heat it in a pan or a clean coffee can, rather than in a beaker or flask. Also, the medium should be stirred frequently to prevent burning.

If only a few adult flies are available, expose a number of the agar-banana covered slides to them at a time. Keep the flies in a large cotton plugged jar and expose the slides for at least 24 hours. The adult flies can be immobilized by placing the jar in a refrigerator for a time.

If a large number of adults are available, immobilize them in the refrigerator and then transfer a couple of males and females to each of the student jars. The flies can be carried on the bristles of a small water color paint brush. Male flies have two narrow bands and one wide band on their abdomens, while the females have five narrow bands on their abdomens. The females are slightly larger than the males, and the tips of the female abdomens are more pointed than those of the males.

Have the students use the low power of their microscopes to search for eggs on their slides. The eggs are white, and each has two threadlike extensions on one end. Hand lenses will prove helpful for observing the later stages of development.

ANALYSIS QUESTIONS (page 271)

1. Fruit flies pass through the following stages: egg, larva, pupa, adult.
2. Answers will vary. Depending on the temperature, the life cycle usually takes from 10 to 15 days.
3. Answers will vary.

Part III: Investigating a Land Community

As in the case of the study of a pond community in Block I, this study is planned to occupy a number of days and to provide students with a full-time field and laboratory experience. It can be handled by asking each student to investigate a separate area, or it can be developed as a group study. In the latter case, one area can be selected and small groups of students can be assigned certain tasks to perform for the class. That is, one group can be assigned the problem of mapping the area, another can work on the study of the physical factors, while a third group can survey the plants and animals of the area.

Mapping the Area (page 271)

Materials: meter sticks, string, stakes.

Caution students to select relatively small plots to study. Of course, if a group study is planned, a much larger area can be used. If suitable plots of land are not available near school, back yards or home gardens can be used, and the study can be performed by individuals working on weekends. In this instance, you may want to assign the study at the beginning of Block II, and have students accomplish those sections that are related to various chapters as those chapters are presented. For example, the study of physical factors might be done to supplement Chapter 8, "Physical Factors and Life."

Studying Physical Factors of the Area (page 271)

Temperature (page 271)

Materials: thermometers.

Students may want to prepare a graph to summarize the temperature measurements. Have them use the temperature in degrees as the units of the vertical axis, and the hour of the day as units of the horizontal axis. Different colors can be used to plot the data for temperature changes in different locations such as in the air, at the soil surface, and under the soil.

Relative Humidity (page 272)

Materials: thermometers, cotton cloth, small container of water.

A special wet-dry thermometer for measuring relative humidity may be obtained from a scientific apparatus supply house.

If it is possible to obtain a number of measurements during a 24 hour period, this data will make an interesting graph. Use relative humidity as the units on the vertical axis, and the hour of the day as the units on the horizontal axis.

Soil water (page 272)

Materials: soil sample, can, oven, balance, funnel, filter paper, graduated cylinder.

Assuming that the students are using a balance that is sensitive to 0.1 gram, only a few grams of soil will be needed for this test. However, if less sensitive balances are used, a much larger sample will be necessary. The soil samples can be weighed in clean tin cans. The weight of the empty can, of course, must be subtracted from the total weight of the can and its soil sample in order to obtain the weight of the soil alone.

The soil can be heated with a Bunsen burner, if an oven is not available. In either case, the soil should be stirred frequently with some metal instrument, such as a spoon, to insure complete drying. If the sample begins to smoke, this is a sign that it has become too hot, and the soil humus is beginning to burn.

Caution students to let the samples cool before attempting to weigh them. To make sure that a sample is completely dry, it may be necessary to heat it for a time, weigh it, heat it again, and weigh it to see if weight is still being lost. When no more weight is being lost as a result of additional heating, the sample is dry.

Soil humus (page 273)

Materials: soil sample, can, Bunsen burner, ring stand, balance

To perform this test, it is necessary to burn away all of the humus in a soil sample. If the soil has a high humus content, a great deal of smoke may be produced. For this reason, caution students to use relatively small samples, and be sure to heat them where the smoke can escape easily. Under a hood with the exhaust blower operating is an ideal place.

You may want to point out that this technique is based upon the assumption that all of the humus will be burned away. Actually, the mineral content of the plant and animal remains will be left in the sample in the form of ash.

Soil pH (page 273)

Materials: soil sample, blue litmus paper, red litmus paper, pH paper, distilled water.

It is important to determine that the water used in this test is neutral. Before using it to moisten a soil sample, test the pH of the water. If it is on the acid side, add single drops of dilute ammonium hydroxide until the water tests neutral. If it is on the alkaline side, add single drops of dilute hydrochloric acid until it tests neutral.

If the color of the moist soil interferes with the determination of the color of the test paper, filter some of the water out of the moist soil using a funnel and filter paper. Then test the pH of the water that comes through the filter paper.

Light intensity (page 274)

Materials: light meter.

Different kinds of light meters are likely to record light intensity in different kinds of units. Thus, it will be difficult to compare readings from various studies if different instruments are used. If possible, use light meters that measure light intensity in units of foot-candles.

ANALYSIS QUESTIONS (page 274)

1. Such physical factors as temperature, relative humidity, light intensity, and air movements are likely to vary considerably during a 24 hour period. Soil factors, such as water, humus content, and pH are less likely to change during a 24 hour period, but these factors may change over a long period of time.
2. The observation that temperature, relative humidity, light intensity, and air movements change considerably during any 24 hour period supports the statement that "The environment is changing constantly."
3. Answers will vary. The observation that the temperature and light intensity vary from place to place at the same time supports the idea that the environment is not the same in all parts of the study area.

Comparing Land and Water Environments (page 274, one period)

In comparing a land and a water environment, you may want to have the students consider specific examples. They might compare the conditions in a pond with the conditions on the shore of that pond. Or, you might ask them to compare the conditions in a large aquarium with conditions in a flat of soil on a shelf nearby. In any case, the students should note the following:

a) Generally, the temperature will vary more in the land environment than in the water environment during a 24 hour period.

b) Organisms in the land environment are likely to be subjected to drying, and may be faced with the problem of maintaining an adequate water supply.

c) Oxygen concentrations usually are much higher in the land environment than in the water environment.

d) Since water absorbs light energy, the light intensity below the surface of the water, where aquatic organisms live, will be lower than it will be at the surface of the land environment.

Studying Habitats (page 275, one period)

A habitat is a place where an organism lives, and depending on the kind and size of an organism, its habitat may consist of a very small space or a relatively large space. For example, the habitat of a fish might include most of the space occupied by the pond in which it lives, while the habitat of a lichen might include a small space on the side of a rock.

ANALYSIS QUESTIONS (page 275)

1. Answers will vary. Evidence that physical conditions vary more on the land than in the water probably will come from measurements of temperature, humidity, and light intensity.
2. Whether an organism will live on the land or in the water is determined by its adaptations.
3. Mosses would be expected to live in a habitat that provides moist soil, which probably will be partially shaded.

Surveying the Plants of a Land Community (page 275, three periods)

Materials: newspapers, 50 large pieces of blotting paper, 2 heavy sheets of cardboard, 2 belts, heavy white paper for mounting specimens, tape, classification guides.

Probably it will be possible to use one or two plant presses for the class. Caution students to write their names on the newspapers they use for their individual specimens, so that they can identify their materials after pressing.

A small group of students can be assigned the task of maintaining the press and changing the blotters when necessary. Wet blotters can be dried in an oven set at low heat, if it is not possible to dry them outside in the sun.

If classification keys are available for the plants in your region, some students may be interested in using these aids to discover family or genus and species names for their specimens.

ANALYSIS QUESTIONS (page 276)

1. Answers will vary.
2. Answers will vary.
3. Answers will vary.

Weed Density (page 277, one period)

Materials: 96 wooden stakes, string, 24 rulers.

Students may need some help deciding whether or not to count a plant whose stems and leaves extend into the plot being studied, but whose roots are not in the area. Have the class decide on a set of rules so that each student is counting in a similar manner. They may decide to count only those plants rooted in the marked area, or they may decide to count those rooted in the area plus those whose stems and leaves extend over two of the sides. The method selected will be determined largely by the kind of plants involved.

If the area is not to be used for a later study, it may be easier to count weeds by pulling them up, one at a time. Or it may be necessary to mark each weed as it is counted in order to avoid counting it again.

ANALYSIS QUESTIONS (page 277)

1. Answers will vary.
2. Answers will vary. There are 43,560 square feet in an acre and 27,878,400 square feet in a square mile.
3. Weed distribution will be affected by the same factors that affect the distribution of other plants. These factors will include soil type, moisture, light, and

temperature. In addition, man's activities will influence this group of plants in particular ways. They may be plowed under the soil or destroyed with weed killing chemicals.

Surveying the Animals of a Land Community (page 277, three periods)

Materials: equipment for collecting and preserving specimens (see *Culturing and Collecting*, page 108 and *Preserving Specimens*, page 111), classification guides.

Caution the students about collecting specimens that are rare or are protected by law. You may want them to limit their studies to observing specimens in natural habitats. Or perhaps a few specimens can be brought to the classroom for further study and later returned to the field.

If classification guides are available for your region, some students may want to identify their specimens as to class or order.

ANALYSIS QUESTIONS (page 278)

1. Answers will vary.
2. Answers will vary.
3. Answers will vary.

Common Pests (page 278, one period)

Point out that animal pests, like weeds, make up a group only because of the way man feels about them. Animal pests are undesirable for one reason or another. They may destroy crops or garden plants, damage stored food supplies, or harm building materials and clothing. They also may carry disease-causing microorganisms that affect man or his domestic plants and animals.

Students may need help in identifying the kinds of organisms that are considered to be pests in your region of the country. You might want to discuss local pests and list the characteristics of those that might occur in the study areas.

ANALYSIS QUESTIONS (page 278)

1. Answers will vary.
2. Answers will vary.
3. Houses may harbor rats in attics, termites in the walls or floors, cockroaches in the kitchens, mice where food is stored, beetles in flour containers, clothes moths in closets, silverfish in cupboards and book cases, and carpet beetles in rugs. Also, flies, mosquitoes, and other flying insects may enter houses through open doors and windows. Some animals, like spiders, that actually do much to control certain animal pests may be looked upon as pests when they occur in houses.
4. The excessive use of pest poisons may affect organisms that are not considered to be pests, and in this way create new problems. For example, as pest poisons are used, these chemicals may enter the food chains in natural communities and, in time, affect some of the very organisms that man is trying to protect, including himself.

Studying Soil Organisms (page 278, 2 periods)

Materials: 12 trowels, 48 paper bags, 24 large pieces of white paper, 24 hand lenses, 24 forceps, 70% alcohol or 5% formalin, small bottles for preserving organisms, 24 microscopes, 24 slides, 24 cover glasses.

While searching through soil samples, the students may find such organisms as snails, slugs, pill bugs, earthworms, millipedes, various insect larvae and pupae as well as adult insects, and eggs of insects, snails, or reptiles. They also are likely to find seeds and various other plant parts.

If students are interested in trying to find microorganisms in the soil samples, have them place a small amount of soil in a little water. Microscope slides can be prepared by putting single drops of the soil and water mixture on a slide. The drop should be covered with a cover glass and observed using low-power magnification. Have the students look for various protozoans, small roundworms, and tiny arthropods, including spider-like mites.

ANALYSIS QUESTIONS (page 279)

1. Answers will vary.
2. Answers will vary.
3. Answers will vary.
4. Answers will vary.

Investigating Interaction Among Organisms (page 279, three periods)

Materials: lichens, clover plants, 12 trowels, 24 hand lenses, grass seeds, 12 flats, topsoil, rulers, 24 microscopes, 24 slides, 24 cover glasses.

After observing samples of lichens with hand lenses, students may want to tear small bits apart in drops of water on microscope slides. These preparations can be covered with cover glasses and observed using low-power magnification. Have the students look for the green algal cells surrounded by the filaments of the fungi.

Similarly, it may be possible to observe nitrogen-fixing bacteria by crushing a small root nodule in a drop of water. Methylene blue stain can be used to stain the organisms. Root nodules may occur on alfalfa or bean plant roots, as well as on clover roots.

In testing for the presence of inhibiting chemicals in soil samples, students may want to use the technique for measuring the rate of plant growth described on page 269. To compare the two groups of plants, have the students plot the data for the test plants and the control plants on the same piece of graph paper. They can use average stem length as the units of the vertical axis, and time in days as the units of the horizontal axis. The two graph lines can be distinguished by using different colors.

ANALYSIS QUESTIONS (page 280)

1. A lichen should be assigned to the foodmaking group since these plants contain chlorophyll bearing cells that carry on photosynthesis.
2. Nitrates may be added to soil by the action of lightning, or they may be released from the bodies of dead plants and animals by the activities of decay microorganisms. Thus, the absence of root nodules does not necessarily mean that the soil lacks nitrates.
3. Answers will vary. Students may note that taller plants tend to shade the shorter ones. In this way, plants compete for light. Shading is related to succession in that the climax vegetation will be dominated by the tallest plants that are adapted to prevailing conditions in an area.

WORD MEANINGS (page 282)

1. agar—material used in fruit-fly culture medium
2. humus—decaying plant and animal material
3. light—energy source for photosynthesis
4. oxygen—a by-product of photosynthesis
5. succession—population changes in a natural community
6. transpiration—process by which water is lost from a plant
7. carbon dioxide—a raw material for photosynthesis
8. nocturnal—organism that comes out at night

SELF TEST (page 282)

1. A bog terrarium would provide favorable conditions for *(a) carnivorous plants.*
2. A freshwater aquarium would provide favorable conditions for *(d) Sagittaria.*
3. A woodland terrarium would provide favorable conditions for *(c) liverworts.*
4. A balanced aquarium is one in which *(d) everything would keep on living even though the aquarium was sealed up.*
5. A bog terrarium should contain soil that is *(b) moist and acid.*
6. Lichens are plant oddities in that they are *(c) made up of two different kinds of plants living together.*

7. A desert terrarium should *(a) be drier than a bog terrarium.*
8. The quantity of oxygen given off by a green plant in a certain amount of time can be used as a measure of the rate of photosynthesis because *(c) oxygen is given off only when food is being made.*
9. When an investigator studies population changes in a microscopic community by removing a drop of material from a culture and counting the number of each kind of organism present, he assumes that *(b) the drop removed is representative of the whole community.*
10. Starfish open clams by holding on to their shells with *(d) tube feet.*
11. Which of the following is the best example of a way fish are adapted for life in water? *(a) the two pairs of fins correspond to the limbs of other vertebrates.*
12. Relative humidity is a measure of *(b) the amount of water vapor in air compared to the amount the air could hold.*
13. Soil pH is a measure of *(a) acid-alkaline condition.*
14. A lichen is *(d) an alga and a fungus.*
15. Chemical inhibitors are most likely to *(b) slow down the sprouting of seeds.*

DISCUSSION QUESTIONS (page 284)

1. Aquariums and terrariums provide investigators with an opportunity to study the habits of organisms in sample communities under laboratory conditions. Such sample communities often are useful in performing certain demonstrations and experiments.
2. The number of animals in a terrarium must be limited in order to assure an adequate supply of food, oxygen, and space for those present.
3. Overgrowth of plants in an aquarium can be controlled by removing plants as they become crowded. Plant growth rates can be slowed by limiting the amount of light that reaches the aquarium. And in some cases, plant overgrowth may be controlled by increasing the number of plant-eating animals in the community.
4. In a balanced aquarium, green plants produce food by photosynthesis and release oxygen as a by-product. They use the carbon dioxide given off by other organisms and thus reduce the concentration of this waste product in the aquarium. Plants also take in and reuse various chemicals that result from the breakdown of animal wastes and the bodies of dead organisms.
5. The environmental conditions in a bog, a woodland, and a desert differ primarily in the amount of water present. The bog is quite moist, the desert is very dry, and the moisture condition of a woodland is somewhere between these extremes. These environments are alike in that they each represent a land habitat with similar atmospheres and light intensities.
6. Photosynthesis is favored by the presence of bright light, a relatively high concentration of carbon dioxide, and a suitable temperature.
7. When white light passes through red cellophane, all colors are absorbed except the red. When white light passes through green cellophane, all colors are absorbed except the green. When white light passes through a piece of red and green cellophanes sandwiched together, all colors are absorbed.
8. In measuring the rate of photosynthesis in *Elodea* by counting bubbles, sources of error include matching the pieces of *Elodea* used in the test and in the control, controlling the temperature and carbon dioxide concentrations, and making an exact count of the bubbles released in a given time period.
9. Even though the relative humidity of desert air is usually low, and thus favors a high rate of evaporation, you would predict that desert plants have

a low rate of transpiration. This is because water is in short supply, and if desert plants are to survive, they must be adapted to conserve the water they have.

10. Succession in a natural community is affected by changes in soil conditions, moisture conditions, and temperature. For example, as the rocks of an area are broken down and soil begins to form, small plants can begin growing. As the soil deepens, larger plants can live in the area, and they may shade the smaller plants causing them to die.
11. Plant growth is favored by a mixture of soil types called loam. The soil should contain a suitable amount of moisture and be maintained at a favorable temperature. Certain chemical substances, including nitrates, must be present for plant growth. In addition, some plants are adapted to grow in soils that have particular acid-alkaline conditions.
12. Root growth is influenced positively by gravity and the presence of moisture. Root growth also may be influenced by the soil type and the presence of chemical inhibitors.
13. A starfish is adapted to life in the sea in a number of ways. It has spines and pedicellariae on its surface that prevent materials and small organisms in the water from collecting on its body. On the upper surface of the central disc is a porous area through which water enters and leaves a series of canals. This water is used to operate the tube feet as the starfish moves about and opens clam shells. There are thin places in the body wall through which the starfish obtains oxygen from the sea water and releases carbon dioxide to the outside.
14. Fish have eyes and respond to objects moving outside of their aquariums. Thus, they possess a sense of sight. They remain upright while swimming and resting, which is evidence of a sense of balance. Fish respond to objects that contact their body surfaces, which indicates the presence of a sense of touch. Fish are also sensitive to chemicals and vibrations in water.
15. The general growth patterns of plants and animals are similar in that the growth rates are relatively slow at first, increase to a maximum rate, and then decrease as the organisms approach maturity.
16. The life cycle of a fruit fly and a moth are similar in that each includes the following stages: fertilized egg, larva, pupa, and adult.
17. The graphs of human growth rates seem to indicate that the most rapid growth occurs in the first 2 or 3 years after birth.
18. In nature, seeds may be "planted" to various depths in soil by such things as wind blowing soil over the seeds, water carrying mud over the seeds, and animals burying the seeds or carrying them into underground burrows.
19. Whenever man eats meat, fish, or eggs, he is a link in a food chain. At the base of every food chain are green plants. Thus, the hens that produce the eggs feed on plant materials.
20. The physical factors of the environment consist of such things as the soil, minerals, water, atmospheric gases, light, and temperature. Green plants must have suitable soil in which to grow. They need certain soil minerals, an adequate supply of water and carbon dioxide, as well as sunlight and a favorable temperature. Animals require an adequate water and oxygen supply, food, and a favorable temperature. They are affected both directly and indirectly by the soil, soil minerals, and light conditions of the environment, since they are basically dependent upon the green plants for their food supplies.
21. a) Relative humidity is measured by using a wet-dry bulb thermometer. The thermometer readings are converted to

relative humidity by using a relative humidity chart.

b) Percentage of water in soil (by weight) can be measured by weighing a wet soil sample, heating the soil to evaporate the water, weighing the dry soil, and calculating the percentage of weight lost.

c) Percentage of humus in soil (by weight) is measured by weighing a dry soil sample, heating the sample to burn out the humus, weighing the heated sample, and calculating the percentage of weight lost.

d) Soil pH is measured by wetting a soil sample with neutral water. A bit of the wet sample is placed on some pH paper, and the color that appears on the paper indicates the pH of the soil.

22. Land and water environments differ in such ways as the following:

a) Temperature varies more markedly in the land environment during a 24 hour period.

b) Organisms in the land environment are subjected to drying, and often face the problem of maintaining an adequate water supply.

c) Oxygen concentrations are higher in the land environment.

d) Light intensity usually is greater in the land environment.

23. A microscope could be used to find out if there were any microorganisms in a water or land community. In this case of the land environment, a sample of soil could be mixed with some sterile water and a drop of this mixture could be studied for the presence of microorganisms. To find out how many microorganisms were present, the number in a small, but known volume could be counted. Then the number in any larger volume could be calculated.

24. Plants are preserved in a plant press by placing the plant specimens in newspapers between absorbent blotters. The blotters are sandwiched between heavy cardboards and are pushed tightly together with weights or belts. The plants become dried as the blotters absorb moisture from them. Dried plant specimens then can be taped to white paper and labeled.

25. When organisms interact in a way that is helpful to them, the interaction is called positive. If the interaction produces harmful results, it is called negative. The alga and the fungus that live together in the lichen aid one another, and thus are said to interact positively. Chemical inhibitors that are produced by one plant may slow down or prevent the growth of another plant. This is an example of a negative interaction.

26. In a land community, the herbivores feed on the foodmakers, and in turn are fed upon by the carnivores. The parasites may feed upon members of any of the other food groups, while the saprophytes feed upon the dead bodies of other organisms.

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BLOCK III MAN AND HIS ENVIRONMENT

CHAPTER 12 The Human Organism

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Plants and animals are adapted to the habitats in which they are generally found. Man is adapted to a land environment.	Things To Do, #1 (p. 306)
2. The Body Framework	The human skeleton provides form and support, protects internal structures, and serves as a place of attachment for various muscles. The skeleton is first formed as cartilage, but in development much of the cartilage is changed into bone.	A Cartilage Section (p. 291)
3. Ligaments and Tendons	Ligaments are bands of tough connective tissue that hold bones together at the joints. Tendons are similar bands of connective tissue at the ends of muscles.	
4. Sprains and Dislocations	Ligaments and tendons are stretched too much when a joint is sprained or dislocated. The result is swelling and soreness of the muscles.	
5. Fractures	Fractures are breaks in bones. If the ends of broken bones are out of place, the bones must be re-set.	
6. Bone Structures		
A. The skull	The skull consists of a number of bones that are more or less joined together in the adult. It pro-	Bone Structures (p. 294)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	vides a rigid protection for the brain.	
B. The backbone	The backbone is made up of parts called vertebrae. Twelve pairs of ribs are attached to vertebrae in the chest region.	
C. Shoulder and arm bones	The shoulder bones support the arms. There is a single bone in the upper arm, two bones in the forearm, and a number of bones in the wrist and hand.	
D. Hip and leg bones	The hip bones support the legs. There is one bone in the thigh, there are two bones in the shin area, and a number of bones in the ankle and foot.	
7. Muscle Tissues	Muscles do their work by contracting. A muscle can pull, but it cannot push.	
A. Voluntary muscles	These muscles have striated cells. Many of them serve to move parts of the skeleton.	
B. Smooth muscles	These muscles have nonstriated cells. They are in the walls of internal organs, and they are not under conscious control.	
C. Heart muscles	These muscles have striated cells. They are found only in the wall of the heart.	
8. Food Transportation	Blood plasma absorbs digested food and carries it to the cells of body tissues.	
9. Oxygen Transportation	The red corpuscles are the primary oxygen carriers.	
10. Blood Functions		
A. Waste removal	The blood plasma transports carbon dioxide and liquid wastes formed in the tissues.	Things To Do, #4 (p. 306) Circulation in a Fish Tail (p. 299) Exercise and Heart Beat Rate (p. 404)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
B. Blood clotting	This is a normal blood function. It depends upon the presence of tiny structures known as platelets.	
C. Heat regulation and fluid control	The blood plays an important role in regulating body heat and water content.	
D. Defense against infections	Some white corpuscles destroy invading germs. Antibodies in the plasma also defend against parasitic invaders.	
E. Other blood functions	The plasma is a carrier of hormones, enzymes, and other substances.	
F. Blood variations	Blood varies from person to person. Four general blood types are recognized.	
G. Blood pressure	Blood leaves the heart under high pressure, but the pressure drops to a low level in the capillaries.	
High blood pressure	High blood pressure and hardening of the arteries are related. Each of these conditions causes the heart to work harder and it may fail if the work load becomes excessive.	

RELATED FILMS

	Min.		
Heart—How it Works	11	B&W	McGraw
The Blood	16	B&W Color	EBF
The Human Body: Muscular System	13	B&W Color	COR
The Human Body: Skeleton	11	B&W	COR
The Human Skeleton	21	B&W Color	UW
The Muscular System	11	B&W Color	UW
The Skeleton	13	B&W	EBF
Tissues of the Human Body	16	B&W Color	Churchill
White Blood Cells	13	Color	McGraw
Work of the Blood	13	B&W Color	EBF

OVERVIEW AND RATIONALE

Chapter 12 introduces the study of the human body, which is used as an example of a living structure well adapted to its environment. The first part of this discussion deals with the body framework: the skull, the backbone, the shoulder and arm bones, and the hip and leg bones.

The three general types of muscle tissue are described, as well as the ligaments and tendons. The relationship of voluntary muscles to the movement of skeletal parts is discussed.

In the second portion of Chapter 12 attenion is directed to the circulatory system and its relationship to the use of energy. The structure of human blood is reviewed, and the relationships of blood to tissue fluid and to lymph are emphasized. Then comes a discussion of heart structure and function, and blood circulation through a system of arteries, capillaries, and veins.

The analysis then turns to a review of circulatory functions. These include food transportation, waste removal, body heat regulation, oxygen transportation, fluid control, defense against an invasion by small parasites, and the distribution of hormones and enzymes to body tissues. Attention is also given to blood clotting, blood types, and the relationship of high blood pressure to the hardening of arteries.

GETTING STARTED

One way to introduce the study of the human body is to display a manikin or chart, and direct a class discussion of the body regions, the thoracic and abdominal cavities, and the larger internal organs. Students probably will have some prior knowledge of gross human structures, but they are likely to be somewhat vague as to the locations and the relationships of various anatomical parts. Ask them to outline the location of similar parts on their own bodies.

From this overview of gross anatomy it is easy to proceed to a study of the skeletal supports. A mounted human skeleton is a valuable visual aid in this study, but in its absence, a chart of the skeleton will serve reasonably well. It is not necessary for students to learn the names of many small skeletal parts. More important is an understanding of the skeleton's functions including its relationship to the skeletal muscles. Students will be able to feel many bones in their hands and arms. Have them try to identify these bones.

You can best introduce the study of muscle tissues by examining the three general types of muscle cells. Then the laboratory exercise on page 296 may be used to develop the concept of how skeletal muscles are arranged in opposed groups. Be sure that the students understand the differences between ligaments and tendons.

Bring the process of circulation into the discussion by explaining that the blood is the carrier of absorbed foods and wastes, and is therefore very much concerned in energy use. You can then take up the composition and functions of blood. The laboratory exercise described on page 299 will help to clarify the functions of arteries, veins, and capillaries. A chart of the circulatory system will prove useful in explaining the blood system and blood flow. To simplify matters, it may prove helpful to deal with two separate phases of circulation: pulmonary circulation, and systemic circulation.

CHAPTER NOTES

The Body Framework (page 288) Prior to birth, the human skeleton begins to develop as a cartilagenous structure. It still contains a large amount of cartilage at birth, but this is gradually replaced by bone elements in early life. Bones of the skull, the breast bone, and the hip girdle are separate in early development, but many of them become fused together in the adult. The extent of this fusion varies somewhat in different individuals, being another evidence of the fact that variation is the rule rather than the exception in nature. Lines of fusion are easily seen when a skull is examined.

The Human Skeleton (page 291) Study of the skeleton and its relationship to skeletal (voluntary) muscle provides a good opportunity to stress the importance of ligaments and tendons. Ligaments hold the bones together at the joints. Tendons are the tough fibrous ends of voluntary muscles, and many of them form attachments to bones. Both ligaments and tendons are types of connective tissue. Tendons that are attached to finger bones can be caused to form ridges on the back of the hand by extending the finger forcefully.

At the base of the skull is a large opening, the foramen magnum, through which the spinal cord issues. It should be noted that the vertebrae provide good protection for the spinal cord by virtue of the neural arches that are borne on their dorsal surfaces.

The shoulder and hip girdles are known respectively as the pectoral girdle and the pelvic girdle. In man, the only solid support for the pectoral girdle is provided by the fact that the proximal ends of the collar bones are attached to the sternum. In birds, reptiles, and amphibians you find a much more substantial support for the pectoral girdle.

Muscle Tissues (page 294) The relationship between muscles and muscle cells should be made clear. A skeletal muscle is made up of many muscle cells, and a certain amount of connective tissue. The connective tissue forms a tendon at each end of the muscle.

The Circulatory System (page 296) Red blood cells have no nuclei. They are produced by much larger cells called erythroblasts that are located in the marrow of long bones. Reserves of these red cells are stored in the spleen, and this gland also acts to destroy worn out red corpuscles. Note that another name for a red corpuscle is erythrocyte.

White corpuscles are of several types. Only some of these types are known to destroy invading germs. White blood cells also vary a good deal in size. Some of them are smaller than red corpuscles, but others are much larger. White blood cells are ameboid, and they can pass through the walls of capillaries to reach injured tissues. Normal blood contains about one white cell for every 700 red cells.

Functions of the Circulatory System (page 300) Tissue fluid is that portion of blood plasma that has seeped through the capillary walls into the intercellular spaces. Some of it gets back into the capillaries again, and is once more a part of plasma. Some tissue fluid also passes into lymph vessels and is then called lymph. Lymph is, of course, similar to tissue fluid, and some of it is being constantly fed back into certain veins.

Note that blood always enters the heart through an auricle and is pumped out by a ventricle. The right ventricle pumps blood to the lungs, and the left ventricle pumps blood to the rest of the body. Heart valves prevent back flow, provided they function properly. But some heart valves are defective at birth, and others become defective because of infections. Such defects may be responsible for abnormal sounds that a physician calls "murmers" when he listens to the heart beat.

Blood Pressure (page 303) It may be difficult for some students to see why blood pressure is so low in the region of the capillaries. The reason relates to the fact that while capillaries are small, they are very numerous. They are a sort of "wide place in the stream," and as a result blood flow slows down as it passes through them. Plasma is thought to leave the capillary on the "high pressure end" to become tissue fluid. Some tissue fluid then enters the plasma again through the capillary wall on the "low pressure end."

LABORATORY SUGGESTIONS

A Cartilage Section (page 291), one-half period)

Materials: microscopes, sections of cartilage tissue.

Cartilage sections may be obtained from any biological supply house. Such a section is largely composed of intercellular substance. Scattered through this substance are small cavities which are occupied by the cartilage cells. These cells are small, and relatively simple in structure.

ANALYSIS QUESTIONS (page 291)

1. The cartilage cell has a cytoplasm and a nucleus. The normal cell membranes are present.

2. When cartilage is torn or damaged, material for the repair of its intercellular substance must come from the surviving cartilage cells.
3. Few cells appear in the average cartilage section. In other words, most of the cartilage material is intercellular substance.

Bone Structures (page 294, one-half period)

Materials: fresh long bone, bone saw or hack saw, microscopes, slides, cover glasses.

This is a good chance to observe how fleshy connective tissue covers a living bone, and how blood vessels connect with the bone structures. If desired, a thin smear of bone marrow can be mounted on a slide and examined for the presence of cells. Bone structure is fairly complex; interested students can find more detailed accounts in various references.

ANALYSIS QUESTIONS (page 294)

1. The cross section has a hollow center filled with bone marrow. Outside of this center is a band of hard bone tissue. The surface is covered by a layer of connective tissue.
2. A living bone contains a variety of cells. These cells must have food and oxygen supplies, and must dispose of their waste products. The blood performs the necessary work of transportation.
3. Bone is a living structure, which contains active cells, but like cartilage, it also contains intercellular substance that has been secreted by bone cells. The fact that bone tissue can grow, and can repair itself, is evidence that it is a living structure.

Muscle Functions (page 296, one-half period)

Materials: none.

Skeletal muscles are generally arranged in opposed groups. When one set of muscles contracts, another set relaxes. This arrangement makes it possible to bend or straighten out an elbow or knee joint.

ANALYSIS QUESTIONS (page 296)

1. The muscles that straighten out the fingers are located in the forearm.
2. Muscles in the forearm have tendons that extend out to the hand and its fingers. You use one group of these muscles in making a ball of your fist, and another group in straightening out the fingers again.
3. All body movements such as walking, running, or throwing a ball depend on skeletal muscles that are arranged in opposed groups.

Circulation in a Fish Tail (page 299, one period)

Materials: live goldfish, blank slide, cotton, rubber bands, microscope or projector.

Use a goldfish that is small enough to be attached to a blank slide easily. Low-power magnification will reveal the blood vessels in the fleshy tissue between the bony tail supports. You can see the blood cells moving along through these vessels.

ANALYSIS QUESTIONS (page 300)

1. If the blood flow is toward the tip of the tail the blood vessel is an artery; if the flow is back toward the head it is a vein.
2. No. The red corpuscles of a fish are not disc shaped, and they have nuclei.
3. No. The smallest vessels you see in the fish tail are capillaries. Blood flows rather slowly in these capillaries. It flows somewhat faster in veins, and most rapidly in the arteries.

WORD MEANINGS (page 303)

A

1. antibody—chemical that destroys microorganisms or neutralizes their poisons.

2. auricle—chamber through which blood enters the heart.
3. hemoglobin—red protein found in certain blood cells.
4. ligament—tough tissue that binds the ends of bones together.
5. marrow—substance that is found in the cavities of long bones.
6. plasma—liquid part of the blood.
7. smooth—type of muscle tissue found in the stomach wall.
8. striated—voluntary muscle tissue.
9. tendon—tissue that binds muscle to bone.
10. ventricle—chamber from which blood leaves the heart.

B

1. anemia—condition due to lack of hemoglobin.
2. artery—vessel through which blood leaves the heart.
3. capillary—thinnest walled type of blood vessel.
4. femur—thigh bone.
5. humerus—upper arm bone.
6. red corpuscle—oxygen-carrying cell.
7. tissue fluid—plasma that has escaped from a capillary.
8. vein—vessel through which blood enters the heart.
9. vertebra—a single part of the backbone.
10. white corpuscle—bacteria destroying cell.

SELF TEST (page 304)

1. False. The presence of a backbone is the "trademark" of a vertebrate.
2. True
3. False. Cartilage is largely intercellular substance.
4. False. Cartilage is present in the adult nose, rib cage, larynx, trachea, and between the vertebra.
5. True
6. False. The skull is made up of a number of bones.
7. True
8. False. They are called vertebrae.
9. False. Bone is a living structure, which contains active cells that must have a blood system to circulate food and oxygen and dispose of waste products.
10. True
11. True
12. False. Muscle cells can only exert a pull.
13. True
14. False. In a complex body, cells are necessarily interdependent.
15. True
16. True
17. False. It does not destroy the cells, but enters them and prevents them from carrying oxygen.
18. True
19. False. It is tissue fluid.
20. False. Action of the human heart is so timed that the auricles fill with blood at the same moment.
21. True. It is carrying blood away from the heart.
22. False. Most digested food is absorbed by vessels in the wall of the small intestine.
23. True
24. True
25. False. Antibodies in the blood neutralize poisons released by microorganisms.
26. True. Their walls are relatively brittle.

DISCUSSION QUESTIONS (page 305)

1. Man's skeleton and the attached voluntary muscles are best adapted to walking or running on the land surface. The bones and muscles are adapted to life on land in a number of ways. The leg and foot muscles serve to support the weight of the body against the pull of gravity. The attached voluntary muscles produce the movements of running or walking on the land surface. Similarly, the arm and hand bones together with their attached muscles are adapted for grasping and moving objects.
2. Bones protect various vital structures; for example, the skull forms a protective case around the brain, and the rib cage protects the heart and lungs. The skeleton also gives form to the

body, and provides places for the attachment of voluntary muscles.

3. Bone is hard because it contains deposits of mineral salts. Cartilage is softer and more yielding because it does not contain these hard deposits. Both provide structure and give form to body parts.
4. A sprain occurs when a joint is stretched so that tendons and ligaments are injured. A dislocation has the same effects, but it also involves the fact that the ends of bones at a joint are out of their normal positions.
5. A fracture in which the bone is merely cracked is not as serious as one in which broken pieces of bone have become separated. The most serious condition exists when a piece of broken bone projects outward through the skin.
6. One marked difference is that neck vertebrae (and especially the first two) are free to move so that the head can be turned. Vertebrae in the chest region have ribs attached to them and have little mobility.
7. Support for the shoulder joint to which the arm is attached depends largely upon the collar bone. If the collar bone is broken, this support is lost.
8. They are fairly similar insofar as the number of bones is concerned. However, the thigh bone is longer than the humerus, and the shin bones are longer than the bones in the forearm. Note also that the hand bones permit a grasping action.
9. Muscles pull your body forward as you push the table, so that your body acts as a lever.
10. Heart muscle cells are striated like voluntary muscle cells. Some of them also have more than one nucleus. Like both voluntary and smooth muscle cells, they do their work by contracting.
11. The advantage in having muscles arranged in opposed groups is that this permits movement of skeletal parts in more than one direction. If a part is moved in a certain way by one set, it can be returned to its original position by another set.
12. Plasma transports absorbed foods, wastes, hormones, mineral salts and enzymes. It contains chemical substances (antibodies) that combat certain germs.
13. Tissue fluid is fluid around the cells in various parts of the body. When it enters lymph vessels it becomes lymph.
14. As blood passes through the lung capillaries, red corpuscles absorb oxygen. The blood then returns to the heart, and is pumped out through arteries to the tissues. Here tissue cells obtain oxygen supplies from the red corpuscles.
15. Carbon monoxide is absorbed by red corpuscles of the blood, and retained by them for some time. As a result, the red corpuscles are prevented from carrying oxygen. Cells of body tissues are soon "starved" for oxygen, and unconsciousness and death follow if the condition persists.
16. The blood has two general defenses against invading microorganisms. Some of them are destroyed by white corpuscles, and some are destroyed or rendered harmless by chemical substances (antibodies) in the blood plasma.
17. Blood enters the right auricle and passes into the right ventricle. Then it is pumped through the pulmonary arteries to the lungs. The pulmonary veins return the blood to the left auricle of the heart. Now the blood passes into the left ventricle and is pumped out to the body tissues.
18. A "capillary network" in a tissue consists of a group of capillaries that connect the end of an artery with the origin of a vein.
19. An artery carries blood that is moving away from the heart. A vein carries blood that is returning toward the heart.
20. The plasma carries two kinds of wastes

away from tissue cells: one of these wastes is carbon dioxide gas, and the other is waste that comes from the breakdown of protein compounds.

21. Blood platelets disintegrate when they come in contact with a rough surface. A chemical compound is released from them which sets up a series of chemical changes ending with the production of a protein that combines with blood cells and platelets to form a clot.
22. Whenever a cell does work some heat is likely to be released. When muscle cells contract, for instance, heat is a by-product. The circulatory system acts to remove excess heat from the tissues. This heat is lost through the skin surface, in air exhaled from the lungs, and in body wastes that are discharged.
23. "Blood type" refers to inherited differences in blood. There are four general human blood types.
24. Blood pressure is highest in the arteries. It drops to its lowest point in the capillaries. Then it builds up again as the blood returns through veins to the heart.
25. High blood pressure is serious because it is associated with hardening of the arteries. Hardened arteries may rupture, and since they resist normal blood flow, an extra work load is placed upon the heart.

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CHAPTER 13 Food for Man

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	The human body requires food from the environment that will provide the chemicals and energy necessary to carry on life processes.	
2. Digestive System	In man, this is a canal 25 to 30 feet long, which includes a number of organs and associated glands.	Things To Do, #1 (p. 325) Investigating Enzyme Action (p. 314)
A. Saliva	Human saliva contains an enzyme that changes starch into sugar.	
B. Teeth	A child develops 20 milk teeth. An adult has 32 permanent teeth. Cavities develop in teeth when the enamel is broken or eroded away.	
C. Pharynx	In man, the pharnyx is the back of the mouth cavity.	
D. Esophagus	This muscular tube conveys foods from the pharynx to the stomach, passing through the diaphragm on the way.	
E. Stomach	The stomach wall contains connective tissue, muscle tissue, blood vessels, nerves and gland cells. The gland cells secrete gastric juice. Enzymes in gastric juice begin the digestion of proteins.	
F. Small intestine	Most of the human digestive process takes place in the small intestine. The pancreas discharges a digestive fluid into the duodenum. This fluid contains enzymes that break down carbohydrates, fats, and proteins. Gland cells of the small intestine secrete another digestive fluid that contains enzymes; these enzymes split proteins and carbohydrates.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
G. Absorption	The end products of digestion are amino acids (from proteins), simple sugars (from carbohydrates), and glycerol and fatty acids (from fats). These products are absorbed by blood and lymph vessels in the wall of the intestine.	
H. The liver	The liver converts excess simple sugars into glycogen for storage. When the blood sugar level is low, glycogen is converted back into glucose. Some muscle cells also form glycogen and store it, and glucose can be converted into fat.	
I. Glucose	Glucose is the principal source of energy for the cells of body tissues.	
J. Fatty acids and glycerol	These substances also serve as sources of energy for body tissues.	
K. Amino acids	Amino acids are used to build and repair the protoplasm of cells. Excess amounts can be converted into glycogen or fat, or can be oxidized to supply energy.	
L. Large intestine	This organ conducts solid wastes to the exterior. Water is recovered from the wastes along the way. The wastes consist of undigested foods and bacteria.	
3. Food Needs	Food needs vary, depending upon age, size, sex, rate of activity, and rate at which foods are oxidized.	Things To Do, #2 (p. 325) Carbohydrate Digestion (p. 318) The Digestive System of a Frog (p. 405) Starch Digesting Enzymes (p. 406)
A. Calorie	This is the unit used to measure the energy value of foods. Energy values of different foods vary considerably.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
B. Roughage	This is material in foods that cannot be digested, and becomes a part of the solid wastes. Either too little or too much roughage in foods can produce digestive disturbances.	
C. Water	The human body is very sensitive to water shortage.	
D. Mineral compounds	Various mineral compounds, including some that contain calcium, iron, and iodine are required by the body.	
4. The Vitamins	Vitamins are substances present in various foods, and required for good nutrition. Lack of vitamin supplies leads to the development of deficiency diseases. Vitamins discussed include A, B_1, niacin, C, and D.	Things To Do, #3, 4, and 5 Vitamins (p. 409)

RELATED FILMS

	Min.		
Digestion (Chemical)	17	B&W Color	UW
Digestion (Mechanical)	17	B&W Color	UW
Food or Famine	28	B&W	Shell
Human Digestion	10	B&W	CON
The Human Digestive System	13	B&W Color	COR

OVERVIEW AND RATIONALE

Chapter 13 is concerned with the ways in which the human body makes use of foods obtained from its environment. Attention is first drawn to some simple conclusions which are frequently overlooked. They include the facts that foods contain the chemicals and energy needed for growth and repair and that foods are usually complex substances that must be broken down into simpler components before the body can use them.

Attention is then directed to the human digestive system and the functions performed by its various organs and glands. The small intestine is described as the main center of digestion and absorption. Mechanical movements that cause foods to progress along the digestive canal are described, as well as the chemical actions of the more important enzymes.

Then there is a discussion of the end products of digestion, and the relationship of the liver to some of them, as well as the functions of the large intestine in water absorption and solid waste disposal.

The next section of Chapter 13 deals with food needs in terms of Calories and the potential energy they supply. The point is made that individuals vary greatly in their Caloric requirements, depending upon various factors that have to do with oxidation rate, age, size, sex, and activity. The body requirements for roughage, water, and certain mineral compounds are also reviewed.

The chapter concludes with a consideration of the better known and more important vitamins, and their role in the prevention of various deficiency diseases.

GETTING STARTED

A good way to introduce this study is to ask the question: "Why does the human body need foods?" When this has been answered in general terms you can go on quite naturally to a second question: "Why is it necessary to digest many foods before they can be absorbed?"

Now you come logically to the subject of enzymes, and their functions in digestive processes. So it is appropriate to do the experiment *Investigating Enzyme Action* on page 314. A chart or model may be employed to trace the passage of food through the digestive canal, and to become familiar with the location and form of the digestive organs and associated glands.

Next, there should be consideration of the end products of digestion (glucose, glycerol, fatty acids, and amino acids): how they are absorbed, and what happens to them subsequently. This study should include the relationship of the liver to the products of carbohydrate and fat digestion.

Attention may now be turned to food needs, and reasons why human individuals vary so greatly in their Caloric requirements. This is another opportunity to emphasize the principle of individual variation. The fact that foods also vary in their Calorie content, as well as in the proportions of protein, carbohydrate, and fat they contain should not be overlooked.

The story of vitamins and their importance in good nutrition provides an appropriate conclusion for this study of foods and food uses. Do not overlook the fact that a varied diet is likely to prevent any serious vitamin deficiency, or that it is possible to have protein or mineral deficiencies.

CLASS NOTES

Saliva and Ptyalin (page 308) The ptyalin in saliva is thoroughly mixed with the food in the mouth and continues to act on the food in the stomach. Here the action of ptyalin continues for some time until the enzyme is neutralized by hydrochloric acid in the gastric juice.

Teeth (page 310) Keeping the teeth free from bacterial colonies that collect around them, especially along the gum line, probably is a factor in preventing rapid decay. The enamel covering of a tooth only goes down to the gum line; the root of a tooth is covered with a softer material called cement.

The Pharynx (page 310) The pharynx is a sort of "crossroads." Foods and liquids are supposed to pass through the pharynx and on into the esophagus. Air must pass through the pharynx and enter the larynx. Of course the cartilage known as the epiglottis closes the opening into the larynx while food is being swallowed, but when we try to swallow and talk at the same time, some food may enter the "wrong tube" and go into the lower respiratory passages.

The Esophagus (page 311) The traveling wave of contraction that follows food on its way down the esophagus is a good example of an automatic reflex, over which we have no conscious control. When we swallow a mouthful of water it proceeds rapidly down to the stomach without any muscular aid, but the wave of contraction follows along behind it just the same.

The Stomach (page 311) This organ has a pouchlike fundus at the end joined to the esophagus, which receives food that has just been swallowed. The other end of the stomach is the pylorus, which tapers gradually to the point where the stomach joins the small intestine. Muscles at the end of the esophagus form a cardiac valve that is located at the entrance of the fundus, and other muscles form a pyloric valve at the entrance of the small intestine.

Smooth muscle in the wall of the fundus exerts sustained pressure upon the food mass, gradually forcing it into the pylorus. Waves of contractions proceed along the pylorus, and some food enters the small intestine whenever the pyloric valve opens. There are about 35 million glands in the stomach lining, which secrete the gastric juice that is mixed with the food mass. In addition to pepsin (protein-splitting), gastric juice contains rennin (curdles milk), and gastric lipase (fat-splitting). The actions of the stomach valves are further examples of reflexes that are not under conscious control.

The Small Intestine (page 311) The three regions of the small intestine are the duodenum, the jejunum, and the ileum. The entire structure is about 20 feet in length. The ileum discharges into the large intestine, but not at its point of origin, so a blind cecum (bearing the appendix) is present. By reference to a chart or model it may be seen that the small intestine forms a coiled mass in the mid-area of the abdomen.

The Liver (page 312) The liver is by far the largest gland in the body, and it has a number of different functions. It produces no digestive enzymes, but it does convert glucose into glycogen and vice versa. This action serves to regulate the amount of glucose in the blood stream at any given time. The liver also acts upon the end products of fat digestion, and in the case of proteins, it changes amino acids so that they can be oxidized to yield energy.

The gall bladder is a temporary storage place for bile. From it comes a cystic duct which joins a bile duct (carrying more bile directly from liver tissues), to form the common bile duct. Sometimes the common bile duct and the pancreatic duct have a common opening into the duodenum near its anterior end. But in some individuals these ducts have separate openings into the duodenum. Moreover, some people have a well developed accessory pancreatic duct in addition to the main pancreatic duct. These are other examples of the many ways in which human individuals vary.

The Pancreas (page 312) This gland is about a half-foot in length. Do not fail to note that it has a dual function, producing digestive enzymes, and also the hormone insulin. The pancreatic cells which produce the digestive enzymes discharge their products into branches of the pancreatic duct and the accessory pancreatic duct. Insulin is produced by groups of cells that constitute the so-called islands of Langerhans in pancreatic tissue.

The Large Intestine (page 313) This structure consists of a pouchlike cecum, an ascending colon, a transverse colon, a descending colon, and a rectum which connects with the anus. Normally there are vast numbers of bacteria in the large intestine, and their activities bring about further breakdown of the solid wastes.

Mineral Compounds (page 317) In addition to the mineral compounds discussed in the text, various phosphorus compounds are required. In studying Chapter 14 you will find that the vital compounds *ATP* and *ADP* contain phosphate groups. These compounds play an important part in cell metabolism. Phosphorus is also required for bone formation.

Vitamins (page 318) Note that under favorable conditions the human body can synthesize both vitamin A and vitamin D. The B group contains at least 10 different vitamins. While marked vitamin deficiencies are not likely to be common in a population that subsists on a varied diet, partial deficiencies often occur in individual cases.

LABORATORY SUGGESTIONS

Carbohydrate Digestion (page 318, one period)

Materials: Bunsen burner, Fehling's solutions A and B, graduate, iodine solution, pancreatin, potato, scalpel, test tubes, watch glasses.

The potato scrapings that are left for 30 to 40 minutes in pancreatin solution should, of course, exhibit the presence of sugar. They will also exhibit the presence of starch, because all of the starch in them has not been digested.

ANALYSIS QUESTIONS: (page 318)

1. After 40 minutes the Fehling's solution test should show the presence of sugar in the first test tube (pancreatin solution), but not in the second test tube (no pancreatin solution). The sugar in the first test tube resulted from the digestion or breakdown of starch molecules.
2. The starch test should be positive for both the first and the second test tubes. In the second test tube no enzyme was present to change starch into sugar. In the first test tube only part of the starch was changed into sugar because not enough time elapsed to complete the process of digestion, and some of the starch may not have come in contact with the enzyme.
3. Answers will vary. The students may know, however, that if you warm the first test tube somewhat, chemical change will proceed at a more rapid rate. Cooling the contents of this tube would have the reverse effect.

WORD MEANINGS (page 323)

A

1. amino acid—end product of protein digestion.
2. duodenum—first section of the small intestine.
3. enamel—hard outer covering of teeth.
4. glycogen—starchlike substance produced from glucose.
5. pepsin—stomach enzyme that functions in protein digestion.
6. roughage—indigestible part of food.
7. saliva—substance that contains a starch-splitting enzyme.

B

1. beri-beri—deficiency disease due to lack of vitamin B_1.
2. Calorie—unit used to measure food energy values.
3. carotene—yellow plant pigment that can be changed into vitamin A.
4. dentine—material that makes up the bulk of a tooth.
5. villi—fingerlike projections on the lining of the small intestine.
6. glycerol—an end product of fat digestion.
7. incisor—tooth adapted for biting.
8. rickets—deficiency disease due to lack of vitamin D.

SELF TEST (page 323)

1. True
2. False. The salivary fluid aids in swallowing, but its *enzyme* serves to change starch into sugar.
3. True. They are the third molars.
4. True
5. False. A sound tooth remains alive and has a blood supply.
6. True
7. False. The diaphragm lies *above* the stomach.
8. True
9. True. It is the pyloric valve.
10. False. The small intestine is the main center for chemical changes.
11. True
12. False. Liver bile contains no digestive enzymes.
13. False. The pancreas secretes a fat digesting enzyme, but fat digestion takes place in the small intestine.
14. True

15. True
16. False. Normally, they contain myriads of bacteria.
17. False. The figure cited is much too low.
18. False. Beef is a much better source of protein.
19. True
20. False. Iron is mentioned specifically in the text, and several other mineral substances are known to be needed.
21. True
22. False. They are *vitamins;* if they are lacking they may cause deficiency diseases.
23. True
24. True
25. False. The Calories might all come from refined foods, such as sugar, which lack needed vitamins and minerals.

DISCUSSION QUESTIONS (page 324)

1. The human body uses food to supply energy and chemical materials necessary for life processes, growth, and repair.
2. Food generally contains a variety of compounds that are not soluble in water, and therefore cannot be absorbed. Digestion breaks down some of these compounds into simpler molecules that form solutions in water and can be absorbed.
3. The incisors and canines serve to bite off portions of food, which are then ground up between the premolars and molars. The smaller the fragments, the greater the opportunity for digestive enzymes to come in contact with them.
4. Above the gum line a tooth consists of dentine covered by a layer of harder enamel. A pulp cavity extends inward through the root of a tooth. Branch nerves and blood vessels occupy this pulp cavity.
5. Cavities can be established by mechanical injuries, such as blows that chip off some of the enamel. Ordinary wear and bacterial action also serve to erode tooth surfaces. Cavities should be cleaned out and filled as soon as they are detected.
6. The salivary enzyme begins the digestion of starch. The main stomach enzyme begins the digestion of proteins. The enzymes of the pancreas act upon all three classes of foods: carbohydrates, proteins, and fats. The enzymes of the intestinal glands act upon carbohydrates and proteins.
7. Contraction of smooth muscles in the various parts of the digestive canal are largely responsible for food movement through the canal.
8. End products of digestion include glucose from carbohydrates, fatty acids and glycerol from fats, and amino acids from proteins. All of these products enter blood vessels and fat products also enter lymph vessels in the region of the small intestine.
9. Simple sugars such as glucose may be temporarily stored as glycogen in the liver and certain muscle cells. Then they are reconverted into glucose when more glucose is needed. The cells of tissues use this glucose as a source of energy. Some excess glucose may be converted into fat and stored. Amino acids are used to build and repair cells. Excess amino acids may be oxidized, or converted into glycogen or fat for storage.
10. The large intestine conveys solid wastes to the exterior. Blood vessels in its wall absorb water from the intestinal contents, which results in a conservation of water supplies—an important factor in the life of a land dwelling animal.
11. Food requirements naturally vary because in early stages of the life cycle young people are growing rapidly, and later on growth slows down and finally stops. Also, some people are more active than other people, some are larger than others, and the rate of energy use which is influenced by hormones is a variable factor.

12. The relationship of eating habits to body weight is simple. If the body uses fewer Calories than are taken in as food, there will be a food surplus and body weight will increase due to fat storage. If the body uses more Calories than are supplied in food, there will be a weight loss.
13. Eating habits are related to the development of deficiency diseases. People who subsist upon a limited variety of foods, and especially refined foods, are very likely to be deficient in one or more vitamins or minerals.
14. If the food contains too little roughage, movement of food through the digestive canal is likely to be slow and irregular, resulting in constipation. On the other hand, too much roughage may result in an irritated condition of the intestines leading to diarrhea.
15. Breathing, perspiring, and the elimination of intestinal wastes and urine reduce the body's water supply. New supply comes from liquids we drink and water that is contained in foods.
16. Calcium compounds are used in bone formation. Iron compounds are essential to the development of red corpuscles. Iodine compounds are required by the thyroid gland. The body uses other mineral compounds, but the students may not be aware of this fact as yet.
17. Removing the husks from rice or other grains results in a loss of vitamins. Other vitamins are lost when foods are soaked in water, or when they are destroyed by the heat of cooking.
18. Years ago, long ocean voyages were associated with a lack of fresh foods, including green vegetables and fruits. Sailors were likely to develop marked vitamin C deficiencies, and to suffer correspondingly from scurvy.
19. Since vitamin D can be formed in the skin when the skin is exposed to sunlight, such exposure tends to prevent vitamin D deficiency. This, in turn, guards against the development of rickets.
20. A "balanced diet" supplies the proper amount of Calories for growth and repair. It also provides the vitamins, mineral compounds, and protein content the body requires.

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CHAPTER 14 Energy Supply and Waste Removal

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	In addition to food, many organisms must have oxygen to break down food molecules. They must also have some means of discharging waste products.	
2. Energy Sources		
A. Anaerobic organisms	Some simple organisms are able to break down food molecules without using oxygen.	
B. Aerobic organisms	Man and many other organisms use oxygen to break down food molecules.	
C. ATP and ADP	ATP molecules contain chemical energy that is used by cells in carrying out their life processes. When an ATP molecule loses chemical energy and some of its atoms, it becomes an ADP molecule. An ADP molecule can recapture the necessary atoms and energy to become an ATP molecule again.	
D. Oxygen supplies	Oxygen is present in the air, and is dissolved in the water of ponds, lakes, streams, and seas.	
3. Human Breathing Structures	In man, the blood receives its oxygen supplies as it passes through the lungs. Structures of the breathing apparatus include the mouth and nasal passages, the pharynx, larynx, trachea, and two bronchi that connect with the lungs. The lungs contain many air sacs. Small blood vessels in the walls of these air sacs provide an opportunity for the	Lung Tissues (p. 331) Breathing Rates (p. 333) Things To Do, #1, 2, and 4 (p. 341)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	blood to discharge carbon dioxide and receive oxygen.	
A. Breathing movements	The lungs occupy two sealed spaces in the thorax. When these spaces expand, the lungs expand also, and vice versa. When you inhale, the ribs are raised and moved outward and the diaphragm is lowered. The lungs expand and air is forced into them by air pressure on the outside of the body.	
B. Artificial respiration	The mouth-to-mouth method is sometimes used to restore the breathing movements of an unconscious person.	
4. Respiration and Disease		
A. Common colds	When you have a cold, various bacteria in body tissues may increase in numbers and produce a variety of symptoms.	Bromthymol Blue as an Indicator of Carbon Dioxide (p. 408) Investigating Carbon Dioxide Production From Yeast Cells (p. 409) Things To Do, #5 (p. 341)
B. Influenza	This disease is caused by viruses, and some outbreaks have been quite severe. Attacks of influenza are sometimes followed by pneumonia.	
C. Pneumonia	Pneumonia is caused by over 30 species of bacteria and at least one virus.	
D. Tuberculosis	This disease is caused by a bacterium. The infection is often centered in lung tissues.	
5. Kidney Functions	The kidneys remove protein wastes, salts, and excess water from the blood stream.	Dissecting a Kidney (p. 334)
A. Kidneys and related structures	A kidney contains many tubules. Wastes drain through these tubules into a cavity from which they pass through a ureter to	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	the bladder. The bladder discharges urine through a urethra.	
B. Protein wastes	Protein wastes from the body tissues are carried to the liver where they are changed into urea. In the kidneys urea, salts, and water are combined to form urine.	
C. Kidneys in health and disease	The kidneys have their heaviest work load when they must remove a maximum amount of waste and have a minimum amount of water available. Certain poisons, severe exposure, and bacterial parasites cause kidney damage. So does hardening of small arteries in kidney tissues.	
6. Skin Functions	The skin covers and protects other tissues, keeps various parasites from gaining entrance, disposes of excess heat, contains end organs of touch, and produces such structures as hair and nails.	
A. Skin structures	The skin has two general layers: an outer epidermis and an inner corium. Each layer is made up of many cells, but the corium is much thicker than the outer layer. The corium contains the roots of hairs, as well as oil and sweat glands.	
B. Heat regulation	The skin loses heat by simple radiation. Evaporation of perspiration also draws heat from the skin.	
7. Skin Problems		
A. Skin growths	Moles are overgrowths of epidermal cells that ex-	Things To Do, #3 (p. 341)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	IDEAS TO BE EMPHASIZED AND ACTIVITIES
	tend down into the corium. Corns are similar overgrowths of epidermal cells, but they are not pigmented like moles.	
B. Burns	The skin can be burned by contact with heat, or because of too much exposure to bright sunlight.	
C. Ivy and allergies	Some people are allergic to a protein of poison ivy. Other allergies are due to proteins in plant pollens and certain foods. Allergies show a tendency to "come and go."	
D. Blackheads and acne	A blackhead develops where an oil duct in the skin has been blocked. In the condition known as acne, many blackheads are formed. An infected blackhead may become a boil.	

RELATED FILMS

	Min.		
Air All Around Us	11	B&W	McGraw
Biological Transformation of Energy	54	B&W	USDA
Control of Body Temperature	11	B&W	EBF
Energy and Reaction	14	B&W	McGraw
Mechanisms of Breathing	11	B&W	EBF
The Human Body: Excretory System	13	Color	COR
The Human Body: Respiratory System	13	Color	COR
The Human Hair	10	B&W	Bray
The Work of the Kidneys	11	B&W	EBF
Why do We Need Air?	13	Color	UW

OVERVIEW AND RATIONALE

Chapter 14 deals with the process of maintaining a good internal body environment, and introduces two very important subjects: how food molecules serve as sources of energy and needed chemical substances, and how wastes are eliminated from the body. In its early stages the use of molecules in cells involves the oxidation process, which is essential to the release of energy.

Within the cell, *ADP* molecules serve to trap chemical energy and certain atoms, and become *ATP* molecules. The *ATP* molecules now act as energy suppliers, when chemical changes take place in the cell protoplasm. When the oxidation of glucose is complete, the end products are carbon dioxide and water.

Oxygen is clearly a vital need of an aerobic organism such as man. Human breathing structures make it possible for the blood to obtain oxygen supplies as it passes through small blood vessels in the lungs. The various respiratory passages such as the pharynx, larynx, trachea, and bronchi are means to this important end, and to the elimination of carbon dioxide waste.

The second part of this chapter is concerned with the disposal of liquid wastes and excess heat. The kidneys and associated structures are the main organs concerned in the elimination of protein wastes, salts, and excess water. The liver, however, plays an important role as it converts the protein waste ammonia into urea. Some body heat is lost in breathing, and some leaves the body with the wastes, but much more passes out through the skin. Water is also discharged by the sweat glands of the skin.

Some attention is given to the illnesses which involve the respiratory organs and the kidneys, as well as to certain common skin growths and infections.

GETTING STARTED

This chapter simply continues to discuss foods. Presumably the students are now aware of the general arrangement of organs in the body cavity. Nonetheless, it may be worth while to examine a chart which features the respiratory structures. This might be followed by the study of lung tissues on page 331.

There are several key points that students need to grasp as they study respiration and excretion. One is that oxygen initiates the breakdown of food molecules in cells. It liberates chemical bond energy that is trapped by *ADP* molecules, which then become *ATP* molecules. Energy supplied by *ATP* molecules appears to be used in a variety of other chemical changes that go on continually in cells.

Another important understanding concerns how the breathing movements take place. Students may find this a little difficult until they realize that the two lungs are suspended in sealed chambers of the thorax, and that a partial vacuum exists around the lungs. They must also realize that lung tissue is elastic. So when the thorax expands, the lungs must expand, and when the thorax contracts, the lungs do likewise because of their elasticity.

It may be a new idea to many students that all of us have a variety of microorganisms in our body tissues throughout life. This, of course, explains why a common cold may produce such a variety of symptoms in different people. Most of the symptoms are due to the increase in numbers of the secondary invaders rather than to the cold itself.

The observation of kidney structures (page 334) will serve to introduce the subject of excretion. At this stage about all the students need to know is that each kidney tubule drains urine into the pelvis of the kidney, from which it goes down the ureter to the bladder.

In studying skin structures, a model or chart will also prove useful. The skin is a fairly complex structure, and a very important one. Students will find special interest in the structure and color of hair, as well as in the perspiration mechanism.

CLASS NOTES

Anaerobic Organisms (page 327) The degree to which anaerobic organisms can tolerate the presence of oxygen varies among different species. The so-called obligate anaerobes must have an environment that is virtually free from oxygen. The facultative anaerobes can tolerate the presence of some oxygen. Anaerobic respiration, which is otherwise known as fermentation, leads to the production of lactic acid in some cases, and alcohol in other cases. Generally speaking, anaerobic respiration does not yield as much energy as aerobic respiration does. Aerobic respiration is, of course, the type in which oxidation takes place.

ATP and ADP Molecules (page 328) *ATP* is adenosine triphosphate and *ADP* is adenosine diphosphate. So *ATP* is an adenosine molecule attached to three phosphate groups, and *ADP* is an adenosine molecule attached to two phosphate groups. If energy and another phosphate group are available, *ADP* may become *ATP*. Or *ATP* can lose one phosphate group and energy, whereupon it becomes *ADP*.

The Lungs (page 330) In man, the left lung is smaller than the right, presumably because the heart occupies some of the space on the left side of the thorax. Also, the left lung has two lobes, whereas the right lung has three. Each lung is surrounded by a layer of pulmonary pleura. A layer of parietal pleura is attached to the diaphragm below, and the walls of the chest cavity above.

Breathing Movements (page 330) The respiratory control center is in the medulla oblongata of the brain. It is particularly sensitive to changes in the amount of carbon dioxide in the blood. We can, however, consciously control the breathing rate within certain limits.

Kidney Functions (page 333) A kidney is made up of renal tubules, branch blood and lymph vessels, nerves, and connective tissue. A ureter is attached to the inner margin of the kidney, and is continuous with the cavity in the kidney that is called the pelvis. The fleshy portion of a kidney is made up of a cortex (outer layer) and a medulla (inner layer).

The Skin (page 335) The epidermis consists of several layers of cells. Cells of its inner layer grow and divide actively, whereas cells near the surface may be virtually dead and are constantly being sloughed off. The corium has two layers and is basically composed of connective tissue, with hair follicles and the bodies of oil and sweat glands located in it. But note that the bases of some hair follicles and the bodies of some sweat glands lie below the skin layer in subcutaneous tissue.

A hair follicle consists of epidermal cells that have grown down into the corium, or the subcutaneous layer. A hair grows from rapidly dividing cells at the bottom of a hair follicle.

An oil or sebaceous gland often has a duct that discharges into a hair follicle, but in some cases the duct opens at the skin surface. The ducts of sweat glands also open on the skin surface.

The skin disposes of heat by (a) conduction and radiation, which does not involve the functioning of the sweat glands, and by (b) the cooling effect when perspiration evaporates on the skin surface. Normally, conduction and radiation is the more important factor.

LABORATORY SUGGESTIONS

Lung Tissues (page 331, one-half period)

Materials: microscopes, sections of lung tissue.

Sections of the type required can be obtained from biological supply houses. Any mammalian lung tissue should prove satisfactory. The air spaces or alveoli of such a section receive their air through bronchioles, which are the air passages that result when a bronchus divides and redivides.

The thin walls around an air space contain branch blood vessels which lie just beneath the surface layer. These walls also contain an elastic type of connective tissue.

ANALYSIS QUESTIONS (page 332)

1. A section of lung tissue appears as many small spaces surrounded by slender fleshy walls.
2. From a bronchus, the air goes through

branch air passageways until it reaches an air sac.
3. Exhaling of air depends upon the elastic nature of lung tissue, which causes it to contract when there is no pull in the opposite direction.

An Investigation of Breathing Rate (page 333, one-half period)

Materials: partner to work with, watch notebook.

Even mild exercise, such as hopping up and down for a few minutes, is sure to increase the breathing rate. The amount of increase is subject to individual variation. It will also depend on how vigorously the subject goes about his exercise. These factors will in turn influence the amount of time required for the breathing rate to become normal again.

ANALYSIS QUESTIONS (page 333)

1. Variable answers, but the breathing rate should increase as a result of exercise.
2. During exercise, muscle cells do work, and more carbon dioxide enters the blood stream. The presence of this carbon dioxide stimulates the brain's breathing rate center, and the breathing rate increases.
3. Variable answers, but it will be a measurable period of time.

Dissecting a Kidney (page 334, one-half period)

Materials: fresh mammalian kidney, sharp knife.

For this observation try to obtain a kidney that still has a portion of the ureter and the renal vein and artery attached to its inner border. A butcher can usually provide an untrimmed kidney if you order it in advance.

After making a longitudinal section of the kidney, locate the pelvis (cavity), and note its relationship to the ureter.

ANALYSIS QUESTIONS (page 334)

1. The small blood vessel brings water and certain wastes that are drained off through the renal tubule.
2. Urea and various salts would soon begin to accumulate in the blood stream.

WORD MEANINGS (page 336)

A

1. allergy—condition caused by reaction to a specific protein.
2. anaerobe—type of organism that can live with little or no oxygen.
3. *ATP*—molecule that supplies energy for life processes.
4. kidney—organ that functions to remove wastes from the blood.
5. sweat gland—structure of the skin that functions in body heat regulation.
6. ureter—tube leading from a kidney to the bladder.
7. urine—a mixture of water, urea, and salts.
8. epidermis—outer layer of the skin.

B

1. aerobe—type of organism that uses free oxygen.
2. carbon dioxide—waste substance removed by the lungs.
3. larynx—structure in which vocal cords are located.
4. mole—pigmented overgrowth of skin cells.
5. pneumonia—lung disease that sometimes follows influenza.
6. urethra—tube that connects the bladder to the outside of the body.

SELF TEST (page 339)

1. True
2. True. For the complete breakdown. Glucose can be partially broken down in the absence of oxygen.
3. True
4. False. In the case of single cells this does not appear to be necessary.
5. False. Earthworms have no lungs and

therefore do not "breathe." But of course, they respire.

6. False. A bronchus is a branch from the trachea in higher animals.
7. True. Blood does not come in *direct* contact with the air in air sacs.
8. False. Lowering the diaphragm increases the cavity of the thorax and the lungs expand.
9. False
10. True. This is the current recommendation in using the mouth-to-mouth method.
11. True. This sort of thing has happened.
12. False. Viruses cause common colds.
13. False. Influenza is caused by viruses.
14. True
15. False. Like any other organ, it *receives* blood through an artery, and *discharges* blood through a vein.
16. True
17. True
18. True
19. True
20. False. Most of it leaves due to radiation from the skin surface.
21. True
22. False. It is an allergic reaction to an ivy protein.
23. True

DISCUSSION QUESTIONS (page 340)

1. Food supplies energy and chemicals that are used in growth and repair.
2. Anaerobic organisms live in the absence or partial absence of oxygen. Aerobic organisms must have oxygen in order to live.
3. Oxygen combines with a glucose molecule to produce the initial breakdown. When a glucose molecule is fully oxidized the end products are energy, water, and carbon dioxide.
4. An *ADP* molecule can become an *ATP* molecule through capture of certain atoms and energy. An *ATP* molecule can lose these atoms and energy and become an *ADP* molecule again.
5. A single-celled organism simply takes in oxygen through its cell membrane by diffusion. In an earthworm oxygen enters the blood in small vessels near the body surface, and is then carried to the various tissues. In a mammal oxygen enters the blood in lung tissue, and is then carried to all parts of the body.
6. In reaching the blood air passes through the mouth or nasal passages, the pharynx, the larynx, the trachea, the bronchi, branches of the bronchi, and the air sacs.
7. When you inhale, the ribs are raised and moved outward, the diaphragm is lowered, and air rushes into the lungs. When you exhale the ribs and diaphragm return to the resting position, the chest cavity becomes smaller, the lungs contract, and air is forced out of the body.
8. The idea in artificial respiration is to force air in and out of the lungs at an approximately normal rate. One of the newest procedures is the mouth-to-mouth method described in the text.
9. A severe attack of influenza or the common cold is sometimes followed by an attack of pneumonia, which is likely to be much more serious.
10. During exercise the muscles are at work and relatively more carbon dioxide is formed. Then the breathing rate increases as the carbon dioxide is discharged through the lungs.
11. The fleshy portion of a kidney contains many kidney tubules together with connective tissue, branch blood vessels, and nerves. Waste drains from the tubules into a cavity along the inner margin of the kidney. A ureter connects this cavity with the bladder. A kidney eliminates urine, which contains water, salts, and urea.
12. Protein wastes are formed in the cells and carried to the liver by the blood. In the liver these wastes are changed into urea. The blood then transports

urea to the kidneys, where it becomes part of the urine.

13. The urine is affected by the amount of water taken into the body, the amount of water lost in perspiration and breathing, and the amount of waste that must be eliminated by the kidneys.
14. Kidney damage can be serious because if urea and other wastes are not removed in sufficient quantities they accumulate in the blood and act as poisons.
15. There are two general skin regions: the outer epidermis, and the corium within. The epidermis forms the surface of the body, and its outer cells are constantly being worn away. Cells of the epidermis give rise to hair follicles and nails, which grow down into the corium. The corium contains a good deal of connective tissue, and the bodies of oil glands and many of the sweat glands. In addition to guarding against invasion by small parasites, the skin layer is a very important factor in disposing of excess body heat.
16. Body heat is decreased by radiation from the skin, the evaporation of perspiration, exhaling air from the lungs, and the elimination of urine and solid wastes. It is increased by the mere act of living, and increases more rapidly during exercise than when the body is at rest.
17. Moles and corns are very similar in that both begin to develop as overgrowths of epidermal cells that extend down into the corium. Moles, however, are generally made up of pigmented cells, while corns are made up of non-pigmented cells and form at points where there is continued irritation.
18. Burns that destroy all or most of the corium are serious because they are hard to heal (skin grafts may be necessary), and because they are likely to leave scars if they involve a large part of the skin area, death may result.
19. A person who is sensitive to poison ivy protein will develop a rash from contact with poison ivy or poison oak. This can be minimized by getting the ivy material off the skin layer as soon as possible.
20. Allergic reactions are reactions to various proteins that are inhaled, touched, or eaten. Some people are sensitive to a given protein; others are not. When a person is known to be sensitive the best defense is to avoid contact with the offending substance.

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CHAPTER 15 Body Controls

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Body responses are under controls which coordinate various actions. Some responses are voluntary and others are involuntary.	
2. Nerve Cells and Nerves		
A. Motor nerve cells	A motor nerve cell receives impulses through its dendrites and sends out messages through its axon which stimulates muscle cells to contract.	
B. Nerve cells	A nerve is made up of bundles of axons, together with small blood vessels and connective tissue.	
3. The Human Brain	Man's brain is better developed than that of other vertebrates. Its parts are grouped around a structure called the brain stem. This brain stem is largely composed of axons.	The Animal Brain (p. 347) Things To Do, #1, and 2 (p. 361)
A. The cerebrum	The human cerebrum is large, and its surface is folded. Cell bodies lie in the gray matter close to this surface. The cerebrum is the highest control center, and it directs our conscious acts.	
B. The cerebellum	This portion of the brain serves to coordinate the functioning of muscles. Such controls are involuntary.	
C. The medulla	The medulla is part of the brain stem, and it connects with the spinal cord. The medulla regulates some involuntary acts which have to do with the tone of blood vessels and the breathing movements.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
D. Cranial nerves	Twelve pairs of cranial nerves are given off by the brain. Among them are nerves that function in smelling, tasting, seeing, and hearing.	
E. The spinal cord	The spinal cord runs the length of the backbone and gives off 31 pairs of spinal nerves. Nerve centers in and near the spinal cord control many involuntary acts.	
F. Injuries to the brain and spinal cord	Nerve centers that control various acts are sometimes damaged by polio. Blows that rupture small blood vessels in the brain can produce lasting damage.	
4. Sight and Hearing		
A. The human eye	The optic nerve connects the retina of an eye with a sight center in the brain. The eye is focused by changing the shape of its lens.	
B. The human ear	The main structures of the human ear are the cochlea and the semicircular canals. From the cochlea messages that we interpret as sounds go to the brain. The semicircular canals act as organs of balance.	
5. Reflex Mechanisms	Reflex arcs control many involuntary acts. Some of them are entirely automatic. Others can be modified by our desire to do so.	Eye Reflexes (p. 353) Things To Do, #3, 4, and 5 (p. 361)
6. Types of Behavior		
A. Habits	Habits are acts that have become largely automatic because they have been repeated so often. Good habits help you do things	Investigating the Effect of Certain Factors on Behavior (p. 410) Investigating Conditioning in Animals (p. 410)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	with greater ease; bad habits are a handicap.	An Effect of Learning on Behavior (p. 411)
B. Memory	Memory is the ability to recall past events.	Problem Solving by Trial and Error (p. 412)
C. Intelligence	Intelligence involves the ability to profit from experience.	Factors that Affect Memory (p. 413)
D. Knowledge	Knowledge is the sum of what a person knows.	
7. Ductless Glands	Ductless glands secrete the hormones that are carried to various parts of the body by blood vessels.	Things To Do, #6 and 7 (p. 361)
A. Insulin	Insulin is a hormone that is secreted by certain cells of the pancreas. If not enough insulin is produced, the body is unable to use sugar properly, and the condition known as diabetes develops.	
B. Thyroxin	Thyroxin is the hormone of the thyroid gland. It controls the rate of oxidation in body tissues. Goiter is an enlargement of the thyroid gland that sometimes develops when the body does not have enough iodine. Some people have underactive thyroid glands; other people have overactive thyroid glands.	
C. Adrenalin	Adrenalin is a hormone secreted by the adrenal glands. It regulates the state of contraction in smooth muscles.	
D. The pituitary body	This gland is attached to the base of the brain. One of its hormones has marked effects upon body size during development.	
E. Sex hormones	The sex hormones are produced by ovaries and testes. Some of these hormones are related to the development of secondary sexual characteristics.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
F. The parathyroids	These small glands secrete a hormone that affects the amount of calcium salts in the blood and the functioning of the muscle tissues.	
G. Puberty	Puberty is a period during life when the secondary sex characters develop. It is a transition stage between childhood and maturity.	

RELATED FILMS

	Min.		
Exploring the Human Nervous System	23	Color	Churchill
Fundamentals of the Nervous System	17	B&W Color	EBF
Habit Patterns	15	B&W	McGraw
Principles of Endocrine Activity	16	Color	IU
The Ears and Hearing	10	B&W	EBF
The Human Body: Nervous System	13	Color	COR
The Spinal Column	11	B&W	EBF

OVERVIEW AND RATIONALE

In order to survive, a complex organism like man must react continually to changes that take place in its internal and external environments. Chapter 15 discusses body controls and the various types of responses they produce. These controls include the fast-acting varieties that are mediated by the nervous system, and the slower-acting controls that depend upon hormones from the ductless glands. It is, of course, the nervous system that stimulates ductless glands to secrete their hormones. So in a very real sense the central nervous system "presides over" all of our responses.

A nerve cell or neuron has a cell body with a nucleus, dendrites that receive incoming messages, and an axon that conducts outgoing messages. A nerve contains a number of axons, some branch blood vessels, and a sheath of connective tissue. The cell bodies of neurons are often grouped together to form nerve centers.

The human brain consists of structures that are grouped around and connected with a brain stem. The cerebrum is the largest of these structures. It is the dominant control center, and the seat of memory and the decisions that determine our voluntary acts. It also contains the centers that enable us to see and hear. The cerebellum is primarily a reflex center which coordinates body balance and the activities of muscles. The medulla is a pathway between the brain and the spinal cord, but it includes reflex centers which affect the tone of blood vessels and the breathing motions. Twelve pairs of cranial nerves connect directly with the brain.

The spinal cord conveys messages to and from the brain. It gives off 31 pairs of spinal nerves that connect with a variety of nerve centers near the spinal cord, and in turn are connected by nerves with the internal organs and other sturctures of the body. The spinal cord and its associated nerve centers control many reflex or largely automatic acts.

Sight and hearing are two of the special senses that we depend upon to know what is happening in our environment. The light-sensitive layer of an eye is the retina, and a nerve connects it with the cerebrum. A lens changes its convexity to produce a focusing action. Cells sensitive to sound waves are located in the cochlea of the inner ear. The nearby semicircular canals contain cells that are sensitive to changes in body position. A nerve connects the cochlea and the semicircular canals with the brain.

Many of our responses are reflex acts. Some of these acts are purely automatic, but others are subject to conscious modifications. Reflex acts are the product of reflex arcs, which are groups of neurons associated with nerve centers in various parts of the body. Habits are responses that have occurred so often that they have become largely automatic. From the biological standpoint they are good or bad depending upon the effectiveness of the responses.

Intelligence depends in part upon memory, which is the ability to recall past events. But intelligence is more than recall, because it involves the use of memory in deciding how to deal with a variety of current problems. It is not the same as knowledge, which is the sum of what a person knows or is able to recall.

The hormones are produced by a variety of ductless glands. These chemicals are discharged into the blood vessels, and carried to various parts of the body where they affect certain tissues. Thus, a hormone of the pancreas, called insulin, serves to regulate the metabolism of glucose in the body. Similarly, a hormone of the thyroid gland determines the rate at which oxidation proceeds in the body tissues.

GETTING STARTED

A good way to introduce the subject of body controls is to discuss several common types of responses, and analyze the extent to which they are voluntary or involuntary. A chart of the nervous system, and another chart showing the locations of ductless glands are likely to prove useful. Be sure that the students understand the difference between neurons and nerves at an early stage, and the fact that a neuron conducts impulses or messages in only one direction.

The observation of a mammalian brain described on page 347 will serve to introduce the students to this important control center. Sectioning a lobe of the cerebrum will show that cell bodies are largely located adjacent to the convoluted surface, and that the interior of the brain consists largely of axons through which messages are conveyed in one direction or another. Some attention should be given to the cranial nerves, and particularly those that are related to the senses of smell, taste, sight, and hearing. In studying the eye and the ear, models will prove useful, because it is difficult to visualize these structures without three-dimensional representations.

Note that the spinal cord has two general types of functions: (a) through its associated nerve centers that lie on either side of the backbone it controls many reflex acts, and at the same time (b) it serves as a pathway through which messages go to and from the brain.

The study of eye reflexes described on page 358 will serve to indicate that while some responses are not under conscious control, others are subject to a measure of control. The various experiments that have to do with different types of behavior (see pages 410-414) indicate that reflexes are of various types, and that some reflexes are far more complex than others.

In undertaking the study of ductless glands it may be helpful to note that some of them are separate organs that seem to do nothing but secrete hormones, whereas others are groups of cells located in a variety of organs such as the pancreas, ovaries, and testes.

Throughout this study, such items as variation in eye color, nearsightedness and farsightedness, relative intelligence, and the rate at which ductless glands produce their hormones may be cited as further examples of individual differences.

CLASS NOTES

Nerve Cells and Nerves (page 343) There are various types of nerve cells in the human body. The motor nerve cell described on page 343 is only one of these types. Other varieties, such as certain cells of the cerebrum have shorter, branching axons. Students may wonder why you cannot see a nerve cell that has an axon three feet long. The answer is that the axon is too slender to be visible.

The Brain and Spinal Cord (page 345) The average human brain weighs about two and one-half pounds. As you might predict, brain size varies among different individuals. There seems to be some relationship between brain size and intelligence, but size clearly is not the only factor involved in intelligence.

Three covering layers (meninges) envelop the brain and the spinal cord. The outer covering is the relatively tough dura mater, the arachnoid is the middle layer, and the pia mater is the inner layer. The ventricles are spaces within the brain. Cerebrospinal fluid surrounds the brain and the spinal cord, and fills the ventricles.

The cerebrum is divided into right and left hemispheres by a median fissure. The human cerebral cortex is a very complex structure, and it is this cortex in particular that makes the human brain superior.

The 12 pairs of cranial nerves are as follows:

I. The *olfactory nerves,* which are associated with the sense of smell.

II. The *optic nerves,* which connect the eyes with the brain.

III. The *oculomotor nerves,* which are related to movements of the eyes.

IV. The *trochlear nerves*, which also are related to eye movements.

V. The *trigeminal nerves*, which connect with chewing muscles and also conduct some impulses from parts of the facial area.

VI. The *abducens nerves,* which, like the third and fourth pairs, are related to certain eye muscles.

VII. The *facial nerves,* which are related to the movement of muscles in the facial area, and to the secretion of saliva and tears.

VIII. The *auditory nerves,* which are associated with hearing and balance, since they connect the inner ears with the brain.

IX. The *glossopharyngeal nerves,* with branches to the throat area, which are related to the sense of taste, and also to the secretion of saliva.

X. The *vagus nerves,* which are concerned with reflex acts relating to digestion, circulation, and respiration. Branches of these nerves extend down into the body cavity.

XI. The *spinal accessory nerves,* which are connected with certain muscles in the trunk of the body.

XII. The *hypoglossal nerves,* which extend to muscles in the tongue.

The spinal cord, like the brain, is composed of both gray and white matter, the gray being dominated by cell bodies, and the white by axons. In the spinal cord, however, the white portion is on the outside. The spinal cord contains a central, fluid filled canal that connects with the ventricles of the brain.

Nerve centers exist on either side of the spinal cord, and are in communication with the spinal cord by way of the spinal nerves. The so-called autonomic nervous system, for example, receives nerves from the spinal cord, and in turn has nerves that extend to glands and muscles within the body. Responses that are mediated by the autonomic system are of the automatic reflex type. They tend to maintain a favorable environment within the body, and this is done without conscious control.

Sight and Hearing (page 348) It is interesting to note that in man, the eye is focused by changing the convexity of its lens. Since this change in lens shape depends upon the contraction of muscles, the lens can accommodate only by becoming more convex, which means that if it is too convex when at rest, it cannot bring an object into sharp focus. The eye of a bird has a mechanism more like that of a camera. In the bird eye, focusing is accomplished by moving the lens forward or backward.

There are two types of light receptors in the human retina: the rods, and the cones. Cones are concentrated in the central area of the retina, whereas rods predominate out toward the retinal margins. We rely upon the cones for seeing objects in bright light, and the rods for seeing objects in dim light. Also, color vision appears to be localized in the area occupied largely by the cones.

The structures in the cochlea of the human ear that are responsible for sound perception are cells on the basilar membrane and the organ of Corti. The auditory nerve receives two branches, one coming from the organ of Corti, and the other from the semicircular canals.

Types of Behavior (page 350) We receive a stimulus and we react to it. Often the reaction is a reflex, which may or may not be consciously modified. But there is a brief delay between receipt of the stimulus and the response. This period is known as reaction time, and it varies in different individuals.

The Ductless Glands (page 354)—Insulin is produced by groups of pancreatic cells known as the islands of Langerhans. When production is deficient, glucose cannot be oxidized at a normal rate, and the blood content of glucose rises. Now sugar appears in the urine and the symptoms of diabetes develop. Meanwhile, fat metabolism becomes faulty, and acid products of this metabolism accumulate in the blood to produce the condition known as acidosis. Severe acidosis is fatal.

Secretion of the hormone thyroxin by the thyroid gland is influenced by the presence of a hormone from the pituitary body. When thyroxin secretion is too low in early life an individual known as a cretin is produced. The disease myxedema is also due to thyroid deficiency, but in this case the deficiency develops during adult life. Thyroid deficiency is often due to lack of sufficient iodine in the diet.

Only some of the better known hormones have been mentioned in the text. For example, the adrenal glands are known to produce more than 30 hormonal substances. Adrenalin is the hormone of the adrenal medulla; its chemical name is epinephrine. Cells of the adrenal cortex, which lie outside of the medulla, secrete about 30 additional hormones.

The pituitary body has an anterior lobe and a posterior lobe. The anterior lobe produces about a half-dozen different hormones, one of them being the growth hormone that is related to giantism and dwarfism. The posterior lobe produces two other hormones.

The ovaries produce at least two different hormones known as estrogen and progesterone. The former is related to normal development of the sex organs. The latter has a similar role, and also influences the development of the breasts during pregnancy. The testes secrete the hormone testosterone, which has effects upon the development of the male sex organs and secondary sexual characteristics.

LABORATORY SUGGESTIONS

The Animal Brain (page 347, one period)

Materials: mammalian brain, sharp knife or razor.

The gray and white areas of the cerebrum should be readily distinguishable. Note also how the cerebrum is connected with the brain stem, including the medulla oblongata.

ANALYSIS QUESTIONS (page 348)

1. Answers will vary, but the important point is that the brain stem is a pathway through which impulses are transmitted and received.
2. The gray matter contains many cell bodies; the white matter is largely composed of axons. Many of the axons in

the white matter come from cell bodies in the gray matter.

3. The folded surface provides a larger total area in which cell bodies may be located. The more intelligent animals have well developed cerebrums that generally have folded surfaces.

Response of the Iris to Light (page 353, one-half period)

Materials: partner to work with, handkerchief.

Expansions and contractions of the iris are purely mechanical reflexes. They cannot be modified by conscious direction. The extent to which an iris is contracted or expanded determines the size of the pupil.

ANALYSIS QUESTIONS (page 353)

1. The advantage of the automatic response is that it quickly adjusts the eye to changes in the amount of light present. It is not necessary to think about this adjustment.
2. Answers will vary, but actually the partner in this test will feel no change as his iris responds to dimmer or brighter light. He cannot control the responses.

The Eye-blink Reflex (page 353, one-half period)

Materials: partner to work with.

This reflex is similar to the adjustment of the iris that has just been tested, but it differs in one significant way. It is a reflex that can be modified by conscious effort.

ANALYSIS QUESTIONS (page 353)

1. The normal tendency to blink the eyes does not require conscious direction. It is a reflex act.
2. Answers will vary, but probably the partner will be able to prevent or modify the response if he concentrates on avoiding the reaction.
3. When an object approaches the eye, the blinking response covers the eyeball and provides a measure of protection.

WORD MEANINGS (page 358)

A

1. cerebellum—brain center responsible for body balance.
2. cochlea—hearing center whose cells connect with the brain.
3. cornea—transparent covering on front of the eye.
4. eardrum—structure that stretches across the entrance to the middle ear.
5. insulin—hormone produced by cells in the pancreas.
6. nerve—bundles of axons and connective tissue.
7. retina—light sensitive layer in the eye.
8. thyroxin—hormone that controls the rate of oxidation in body cells.

B

1. cerebrum—highest control center of the brain.
2. diabetes—disease in which body fails to use its sugar supplies properly.
3. eustachian tube—structure responsible for regulating pressure in the ear.
4. iris—part that controls the amount of light entering the eye.
5. lens—eye part that changes shape to focus image on the retina.
6. axon—carries messages away from nerve cell body.
7. pituitary body—source of hormone related to the growth of giants.
8. semicircular canals—ear structures involved in maintaining balance.

SELF TEST (page 359)

1. True
2. True
3. False. Nerve cells have both cytoplasms and nuclei.
4. True
5. True
6. False. Axons conduct impulses only in one direction.
7. False. They also contain small blood vessels and connective tissue.
8. True

9. False. The memory center is the cerebrum.
10. False. Such acts are controlled by the cerebrum.
11. True
12. True
13. True
14. False. Focusing is accomplished by the lens.
15. True
16. False. When the eardrum vibrates, the vibration is carried to the inner ear by three small bones.
17. False. It is filled with liquid.
18. True
19. False. You have made a conscious decision.
20. True
21. False. He may have had only limited opportunity to learn.
22. False. Nerve controls act much more rapidly.
23. True
24. False. It is due to a diseased pancreas.
25. True
26. True
27. False. A giant is likely to be the result of an overactive pituitary gland.
28. False. Hormones secreted by the male and female sex organs are responsible for the development of secondary sex characteristics.

DISCUSSION QUESTIONS (page 360)

1. There are innumerable ways in which the body may respond to forces in the environment. Some of the responses are voluntary and others are involuntary. Answers will vary widely, and quite properly so.
2. As in question one, answers will vary. But one obvious answer relates to the way in which digestive glands begin to secrete their enzymes when food enters the digestive canal. Another might be the way in which the liver goes about storing glycogen when there is excess sugar in the blood.
3. Voluntary acts require conscious attention and decision. You decide to get up and walk across the room, and you use your back and leg muscles to do so. Or, you decide to toss a ball of paper into a wastebasket, and your arm muscles do the work. Involuntary acts do not require attention. Your iris expands in bright light without conscious direction. Your eyes blink when a small insect approaches one of them.
4. A nerve cell or neuron has a cell body that includes a cytoplasm and a nucleus. It generally bears processes in the form of dendrites and an axon. The axon of such a cell is combined with other axons, small blood vessels, and connective tissue to form a nerve.
5. Motor nerves send messages to skeletal muscles, stimulate the muscles to contract, and move body parts such as arms and legs.
6. The human brain consists of a brain stem to which the cerebrum and cerebellum are attached. The brain stem is continuous with the spinal cord. The cerebrum is the center for memory, intelligence, conscious decisions, and special senses such as sight and hearing.

   The cerebellum coordinates muscular movements. The medulla, which is part of the brain stem, contains reflex centers which affect the tone of blood vessels and preside over the breathing motions.
7. The spinal cord is a pathway for messages going from the brain to the muscles and glands in the body trunk. The spinal cord also contains nerve centers that control reflexes in the body trunk. Damage to the backbone and spinal cord can block the normal flow of impulses to the legs and result in paralysis.
8. Some attacks of polio result in damage to nerve cells in the spinal cord. As a result, certain muscles may become paralyzed. In some cases other nerve centers take over the former functions of damaged nerve centers.
9. A blow on the head may damage motor centers in the brain. This, in turn, may result in temporary or permanent

paralysis of muscles in other parts of the body, as well as loss of muscular coordination if the cerebellum is involved.

10. The eye has a transparent cornea across its front surface. Beneath lies the colored iris, which expands and contracts to control the amount of light admitted through the pupil. Behind the pupil is a lens with attached muscles that can make the lens more convex and bring objects into focus. Such objects are focused on the retina at the back of the eye, whose cells are light sensitive. Messages from the retina travel through the optic nerve to the brain.
11. Nearsighted and farsighted people usually have eyeballs that are not quite normal in shape. The distance between the lens and the retina is too great in a nearsighted person, and too small in a farsighted person.
12. An eardrum stretches across the opening to the middle ear, and it is caused to vibrate by sound waves. This vibration is transmitted to the window of the inner ear by three small bones that extend across the middle ear. The inner ear is filled with fluid, which is now set in vibration, and cells of the cochlea send corresponding messages to the brain. These messages are responsible for what we call sound. The semicircular canals of the inner ear also send messages to the brain which have to do with balance and body position.
13. The ear can be damaged by blows or other mechanical effects. It can also be damaged by infections due to the presence of microorganisms. Mechanical injuries should, of course, be avoided if possible. Infections should be treated promptly to forestall permanent injury.
14. A reflex act is an act performed by a reflex arc. One or more axons carry a message to a nerve center, and one or more axons of motor neurons carry a response message to appropriate muscle cells. The reflex tends to be automatic, but many human reflexes can be modified by conscious control.
15. Habits are acts that become more or less automatic through long practice. At first, they usually require conscious control, but the need for this control becomes less and less as the habits are continued.
16. It is sometimes said that there is a right and a wrong way to do almost everything. If, for example, an effective habit of catching a ball is practiced from the outset, the result is likely to be satisfactory. But if a bad habit of catching the ball is learned, frequent failures are likely to occur.
17. Intelligence is the ability to learn or profit from experience. Knowledge is the sum of what has been learned and can be recalled at any given time. Memory is essential to both, since it is the ability to recall past experiences.
18. A hormone, like a nerve fiber, can stimulate a muscle or gland to perform certain acts. But the hormone action is generally gradual, whereas the nerve action is rapid. Also, the hormone "message" travels in the blood, while the nerve "message" travels along a nerve fiber.
19. Basically, diabetes represents failure of the body to oxidize sugar normally, due to lack of the hormone insulin. Victims of this disease are given enough insulin to counteract the deficiency.
20. The largest gland in the throat area is the thyroid, which secretes the hormone thyroxin. Thyroxin regulates the rate at which food molecules are oxidized in cells of body tissues. Four small parathyroid glands in the same area produce a hormone which affects calcium salt content of the blood and body tissues, and the functioning of muscles.
21. A thyroid gland may be either underactive or overactive. If it is underactive in early life a cretin may be produced. A simple goiter may also develop. The underactive tendency is dealt with by supplying thyroxin and/or iodine. An

overactive thyroid gland produces another type of disease which can be dealt with by removing a portion of the thyroid tissue.

22. Adrenalin causes contraction of muscles in the walls of blood vessels, slows down digestive processes, and causes the heart to beat more rapidly.
23. A hormone of the pituitary gland has profound effects upon growth during early development. If this hormone is deficient, a dwarf is the result; if it is overabundant, a giant is produced.

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CHAPTER 16 The Control of Diseases

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Three centuries ago the average human life lasted about 20 years. This was largely because microorganisms were unknown; the nature of germ diseases was still a mystery. Pasteur demonstrated the nature of germ diseases in the latter half of the nineteenth century.	
2. Parasites and Diseases	When germs become sufficiently numerous in any body tissue an infection exists and the symptoms of disease appear.	Trichina Worms (p. 369) Things To Do, #1, 2, and 3 (pp. 379-380)
A. Bacteria and diseases	Some germs are bacteria. There are three general types of bacteria: the cocci, the bacilli, and the spirilla. Many communicable diseases are caused by such bacteria.	
B. Protozoans and diseases	Some germs are protozoans. Diseases caused by these organisms are most common in tropical areas.	
C. Protists	Some germs are borderline organisms. Some of them are similar to bacteria; others are more like the protozoans.	
D. Viruses and diseases	Viruses are composed of ultra-small particles. There is question whether they are living or nonliving substances. They produce a number of diseases that have the general characteristics of germ diseases.	
E. Fungi and infections	Some human diseases are caused by tiny parasitic fungi.	
F. Worm parasites	Man is also attacked by various worm parasites, in-	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	cluding tapeworms, flukes, and roundworms.	
Trichina worms	The trichina worm is a roundworm that lives as an adult in the intestines of man, pigs, rats, and other animals. Its young form cysts in the muscles of their hosts. When present in large numbers these parasites can cause paralysis and death.	
Hookworms	Hookworms are roundworms, and enter the body as larvae that bore through the skin. The adult worms live in the human intestine, and produce eggs that pass out with the body wastes.	
3. How Disease Are Spread		
A. Epidemics	Epidemics are outbreaks of germ diseases in which many people are affected at the same time.	Flies and Germs (p. 372) Things To Do, #4 (p. 380)
B. Diseases spread by contact	Many diseases are spread in this manner. In some cases the disease is passed from one person to another by actual contact; in others by near-contact.	
C. Food, water, and disease	Various small parasites can live in food or water. Among them are the germs of cholera, dysentery, and typhoid fever.	
D. Diseases spread by insects and arachnids	Certain human diseases are of this type. Among them are malaria, yellow fever, plague, and the typhus fevers.	
4. Body Defenses	The body has a number of natural defenses against germs. They include the skin barrier, the acid in gastric juice, the harmless organisms that live in the	Things To Do, #5, and 6 (p. 380) Testing for the Presence of Bacteria and Fungi (p. 414)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	intestines, white corpuscles, and antibodies.	
A. Immunity	Immunity to a disease depends upon the presence of a specific antibody in the blood. We are born with some immunities and develop others. Some immunities last longer than others; some immunities are more effective than others.	
B. Smallpox immunity	Centuries ago Oriental people developed a method of making themselves immune to smallpox by introducing old smallpox material into the skin. Then Dr. Edward Jenner discovered a safer way to make people immune by using cowpox material. Jenner's method is called vaccination.	
C. Types of immunity	Active immunity is developed when your own body produces the antibodies. Passive immunity occurs when you receive antibodies from the blood of another person or a laboratory animal. Active immunities are generally more lasting than passive immunities.	

RELATED FILMS

	Min.		
Bacteria	19	B&W	EBF
Cancer	29	B&W	IU
Infectious Diseases and Man-made Diseases	11	B&W Color	COR
Microscopic Fungi	15	Color	EBF
Simple Plants: Bacteria	13	B&W Color	COR
The Rival World	27	Color	Shell
Unseen Enemies	23	Color	Shell
Viral Genes	29	B&W	IU

OVERVIEW AND RATIONALE

Chapter 16 introduces the subject of human diseases that are brought about by parasitic attacks. It emphasizes the important fact that some human parasites are tiny things such as viral particles, while others are fairly large in size. It also indicates that our defenses against parasitic attacks have been greatly improved during the past century.

The point is made that when germs become sufficiently numerous in a tissue, a state of infection exists. Such germs may be bacteria or protozoans. Viruses can also produce infections, and so can various microscopic fungi. Parasitic worms cause a variety of human diseases.

The discussion then turns to ways in which germs are conveyed from the body of one host to the body of another host. Some germs are generally spread by contact or near-contact, some in contaminated food and water, and others are carried to human hosts by certain insects and arachnids.

The final portion of this chapter deals with body defenses, including immunities. These defenses are of various types, including the natural barrier of the skin, the action of the acid in gastric juice, the germ destroying activities of some white corpuscles, and the chemical substances in blood plasma that we call antibodies. Specific immunities are based upon the presence of corresponding antibodies.

A significant distinction is brought out at this point: the difference between an active immunity and a passive immunity. Active immunities may be developed in the process of having the diseases themselves, or because vaccines have been introduced into the body. It is, of course, much safer to develop such an immunity as a result of receiving a vaccine, than to develop it by suffering an active attack of the disease concerned. You may also note that the relative security provided by immunities varies, and that some of them are comparatively short-lived. Passive immunities usually are not as lasting as active immunities.

GETTING STARTED

A good way to introduce the subject of disease control is to review the events that led to the discovery of germs, and the profound effect that the discovery had upon human health and longevity within a comparatively short span of years. At the same time slides can be used to show the nature of various microorganisms that cause diseases. For this purpose the 2 × 2 slides sold by supply houses are excellent. Early in this study you should make certain that students understand the nature and causes of infections.

The subject of worm parasites can be opened up by doing the exercise on trichina worms (page 369). This observation brings out the significant and practical fact that you cannot see some worm cysts with the unaided eye. In fact, the adults of some worm parasites are microscopic in size.

The study may now proceed to a consideration of how germs are conveyed from one person to another. You may note that many of our germ diseases are spread by contact or near-contact, and indicate what this may mean in times of epidemics. The importance of pure food and water supplies, in turn, relates to the germs that enter our bodies through these media. Insect and arachnid borne diseases should also receive attention, and the observation of fly structures (page 372) brings home the fact that some germs may be conveyed to things we swallow by purely mechanical carriers.

The consideration of antibodies leads naturally to the discussion of immunities. The case of smallpox is challenging because of its historical background. It is also unusual, in as much as cowpox vaccination gives protection against smallpox itself. The defense against tetanus has been emphasized because it involves ways of conferring both active and passive immunity. In dealing with this subject of immunity you should not fail to note that it is much safer to become immune by receiving a vaccine than it is to become immune by developing an active case of the disease. Also, that immunities are likely to become less effective with the passage of time, and that immunity to one disease does not provide protection against other diseases.

CLASS NOTES

Parasites and Diseases (page 363) When the nineteenth century dawned, the association between germs and communicable diseases was still unknown. In the mid-portion of this century a Viennese physician, Dr. Ludwig Ignaz Semmelweis, discovered a technique for controlling child birth fever (puerperal sepsis) which at that time was rampant in the lying-in hospitals of Europe. But Dr. Semmelweis did not discover germs.

During the latter half of the century the French chemist, Louis Pasteur, developed techniques for raising bacteria in cultures, and in a series of brilliant experiments, demonstrated that certain bacteria were the cause of diseases such as anthrax and cholera. He also devised ways to immunize animals against anthrax and cholera. Meanwhile, across the English Channel, Lord Joseph Lister, a physician, had begun to use antiseptics in the treatment of compound fractures with great effect.

Soon thereafter Dr. Robert Koch of Germany identified the germs responsible for several diseases, and formulated the famous "Koch's Postulates," which in substance are rules for establishing the cause-and-effect relationship between a given microbe and a disease. Other research workers were also making contributions, and in the early part of the twentieth century, it became common knowledge that the communicable type of disease was of germ origin.

Bacteria were the first germs to be identified as such. Pasteur searched in vain for the organism of rabies, which ultimately proved to be a virus whose particles could not be revealed by any magnification available in Pasteur's day. In fact, it was not until the electron microscope was perfected that the physical appearance of viral particles became known.

Borderline organisms that cause diseases include the following:

Disease	*Responsible organisms*
Actinomycosis	A microscopic fungus
African tick fever	A rickettsia
Blastomycosis	A microscopic fungus
Brucellosis	A brucella organism
Coccidioidomycosis	A microscopic fungus
Cryptococcosis	A microscopic fungus
Histoplasmosis	A microscopic fungus
Malaria	Four species of sporozoans
Q fever	A rickettsia
Relapsing fever	A spirochaete
Rickettsialpox	A rickettsia
Ringworm	Various microscopic fungi
Rocky Mountain spotted fever	A rickettsia
Scrub typhus	A rickettsia
Sporotrichosis	A microscopic fungus
Syphilis	A spirochaete
Typhus (endemic) fever	A rickettsia
Typhus (epidemic) fever	A rickettsia
Yaws	A spirochaete

We tend to think that worm parasites are organisms large enough to be seen without magnification. And to be sure, some of them are, but others are very small. The disease filariasis of tropical and subtropical areas around the world is caused by a tiny roundworm known as a microfilarian. Larvae of this microfilarian are transmitted to man by mosquito bites.

Note that some worm parasites require two hosts to complete their life cycles; others require only one host. In cases wherein two hosts are necessary, some worm parasites may have two hosts of the same species, whereas others require two hosts of different species.

How Diseases Are Spread (page 369) The text indicates that human individuals may harbor the germs of certain diseases without showing any ill effects, and thus become carriers who are potential sources of infection. We must also contend with the fact that we share about half (so far as we now know) of our small parasites with other animals, including the common domesticated types. Thus, reservoirs of infection are around us at all times. The microbe that produces tetanus, for example, lives in the intestines of horses, without injuring these equine hosts.

Many infections are spread by contact because large numbers of people are in near-contact with one another. Some individuals who spread the infections appear to be perfectly well, but may act as carriers. In most germ infections an incubation period exists between the time when the infection is incurred and the time when the first symptoms of illness appear. In the case of chicken pox, for example, the incubation period is two or three weeks, and in the case of whooping cough it is one to three weeks.

Insect and arachnid-borne diseases are conveyed to man by a number of arthropod species. A partial list of diseases and vectors is as follows:

Disease	*Vector*
African tick fever	Several species of old-world ticks
Colorado tick fever	Tick of the genus *Dermacentor*
Filariasis	Mosquitoes of the genera *Culex, Aëdes, Anopheles,* and *Mansonia*
Malaria	Several species of *Anopheles* mosquitoes
Phlebotomus fever	An old-world species of sand fly
Plague	The rat flea
Relapsing fever	A louse of the genus *Pediculus*
Rocky Mountain spotted fever	Ticks of the genera *Dermacentor* and *Amblyomma*
Scrub typhus	Larval mites
Tularemia	Deer fly, wood tick, dog tick, lone star tick, and one species of *Aëdes* mosquito
Yellow fever	Mosquitoes of the genera *Aëdes* and *Haemagogus*

Malaria (page 372) There are four species of human malaria organisms, and a victim may be infected by more than one type. The presence of malaria organisms in the body leads to the destruction of red corpuscles. When the urine becomes colored by substances from red corpuscles that have been destroyed, the victim has "black-water fever." The chill that comes periodically in malaria infections is due to a toxin called melanin.

The case of malaria presents an opportunity to point out the difference between a biological vector and a mechanical vector. Part of the malaria organism's life cycle takes place in the stomach of an *Anopheles* mosquito. The mosquito is not infective until this phase of the life cycle has transpired. In this case, the mosquito is a biological vector. On the other hand a housefly, in the course of minutes, may transport some typhoid germs from waste substances to foods. In this case the housefly is a mechanical vector, because no part of the typhoid germ's life cycle takes place in the fly's body.

Body Defenses (page 373) The protein of an invading parasite acts as an antigen in the body of a host. When an antigen is present, the body of the host may develop a corresponding antibody, which in one way or another protects the host against the invader. Antibodies vary in their nature. One type, known as antitoxin, neutralizes the poisonous wastes of an invading parasite. The type of antibody called a lysin destroys the invader, but an opsonin merely makes the invader susceptible to destruction by white corpuscles. An agglutinin causes groups of the tiny parasites to clump, and it is believed that this also makes them more available to the defending white corpuscles.

LABORATORY SUGGESTIONS

Trichina Worms (page 369, one-half period)

Materials: microscope, section of pork tissue bearing trichina cysts.

The number of cysts in a given section depends upon the extent to which the host (from which the section came) was infested. Some infestations are much heavier than others. The actual appearance of a given cyst and the worm within it varies according to the plane through which the sectioning knife happened to pass. In some cases the sectioning knife will merely scrape the surface of a cyst; in others, the cyst will be sectioned so that its interior is exposed.

ANALYSIS QUESTIONS (page 369)

1. Answers will vary. The number of cysts will depend upon the extent to which the host was infested. Note that a host is *infected* by germs, but *infested* by worm parasites.
2. The answer is negative. The cysts are microscopic, a fact which the students have verified in this observation.

Flies and Germs (page 372, one-half period)

Materials: housefly, scissors, forceps, blank slide, cover glass, microscope.

The legs and wings of a housefly bear innumerable bristles and hairs. The same is true of most other parts of a housefly's body. Because these flies crawl around on all sorts of dead material, they come in daily contact with vast numbers of bacteria, some of which are likely to be germs.

ANALYSIS QUESTIONS (page 372)

1. On the wing the hairs are more or less all over the surface, with the larger hairs or bristles mainly on the veins. The legs are generally hairy, but their bristles tend to be concentrated around the joints.
2. These hairs and bristles collect deposits of dirt; germs are almost inevitably present in this dirt.

WORD MEANINGS (page 377)

A

1. "athletes foot"—a disease caused by a fungus.
2. bacillus—rod-shaped bacterium.
3. carrier—a person who is not ill, but can pass disease germs to another person.
4. cowpox—disease from which material used in smallpox vaccine is obtained.
5. gastric juice—acid-containing substance that helps to protect the body against germs in the stomach area.
6. immunity—protection provided by antibodies.
7. infection—any condition caused by rapid increase of germs in body tissues.
8. mosquito—organism that spreads malaria.
9. tapeworm—a parasite that may grow to be many feet long.
10. tetanus—disease caused by an anaerobic bacterium.

B

1. antibody—chemical substance in blood plasma that acts against a particular germ.
2. coccus—ball-shaped bacterium.
3. contaminated—word used to describe food or drink that contains germs.
4. epidemic—condition in which many people become ill with the same disease.
5. hookworm—a parasite that lives part of its life cycle on the soil surface.
6. malaria—disease caused by protozoans that attack red blood cells.

7. parasite—any organism that lives at the expense of another organism.
8. vaccine—substance that stimulates the body tissues to produce antibodies.
9. virus—the smallest of the disease-causing parasites.
10. white corpuscle—body cell that has the ability to destroy germs.

SELF TEST (page 378)

1. True
2. False. The relationship of germs to diseases was not established until the latter half of the nineteenth century.
3. True. It was supposed to "disgust" demons out of the body.
4. True
5. True. "Microbe" and "germ" mean the same thing.
6. False. Most healthy people, for instance, have some pneumonia germs in their respiratory tissues, to say nothing about a lot of other possibilities.
7. False. Cases of dysentery and malaria appear now and then in temperate areas.
8. True
9. False. Various common diseases are caused by viruses.
10. True
11. False. They are only conveyed when the uncooked flesh of an infested animal is eaten.
12. False. After cysts are formed in the muscles, the parasites are beyond the reach of drugs.
13. True
14. False. Man "shares" many germs with other animals.
15. True
16. True
17. True. Such a person is a carrier.
18. False. The mosquito must first bite an infected person, and then an incubation period must elapse before the mosquito can become infective.
19. True
20. True
21. False. Antibodies are very specific in their actions.
22. True
23. True
24. False. He has developed his own antibodies; therefore, it is a case of active immunity.
25. False. Active immunities generally last longer than passive immunities.

DISCUSSION QUESTIONS (page 379)

1. Three centuries ago people had all sorts of ideas about disease epidemics. An angry providence, well-poisoners, demons, dangerous night air, the appearance of comets, and various other things were blamed. Many of the drugs used at this time had no possible value. In addition to those listed in the text, these "drugs" included powdered "unicorn" horn, powdered pearls, crocodile dung, and various other items of either plant or animal origin.
2. An infection occurs whenever germs become sufficiently numerous in a tissue to produce the symptoms of disease.
3. There are three general groups of bacteria: the spherical cocci, the rod-shaped bacilli, and the spiral-shaped spirilla.
4. The airplane provides rapid transport of many people to and from tropical areas. As a result, tropical diseases tend to become more important to people who live most of the time in other parts of the world.
5. A virus behaves like a living thing when it is in a host cell. Here it can produce new viral particles and undergo hereditary changes. But when the virus is not in a host cell it behaves like a nonliving chemical substance.
6. A trichina worm requires two hosts to complete its life cycle, but they may be hosts of the same species. Adults begin their careers in the stomachs and intestines of one host. Here the females soon bear microscopic larvae that bore into the walls of the digestive canal, enter the blood vessels, and are carried to various parts of the body. The lar-

vae now leave the blood stream and form calcareous cysts in muscle tissue. This is a "dead end" for the larvae unless the uncooked flesh of the first host is eaten by another acceptable host. When the latter happens, the cyst walls dissolve in the stomach of the second host, the larvae emerge, and soon become adults. Now the cycle begins again.

7. Tapeworms and trichina worms can generally be avoided by cooking meat (including fish in the case of some tapeworms) before it is eaten. Hookworms can generally be avoided by wearing shoes, and not lying on the ground in hookworm country.
8. Garbage is likely to contain pork scraps of one kind or another. If it is cooked before it is fed to pigs, any trichina larvae that may be in the pork scraps will be killed. When garbage is treated in this manner, infested pigs are much less common, although an occasional pig may get the infestation by eating a dead rat.
9. If worm cysts are numerous in muscle tissues the affected parts may become paralyzed. A paralysis that impairs the functioning of vital organs may lead to death.
10. Epidemics are much less common today because (a) many people are immunized against diseases that are likely to become epidemic, and (b) we have much better drug defenses against some of these diseases.
11. Diseases of various types are spread from person to person by contact or near-contact, in contaminated food and water, and through the agency of certain insects and arachnids.
12. In the first place, a housefly is covered with hairs and bristles that provide an excellent lodging place for germs. In addition, a housefly frequents places where germs are likely to be, visiting garbage cans, the bodies of dead animals, and piles of refuse.
13. A malaria parasite in the human blood stream enters a red corpuscle in which it grows and divides to form many young parasites. The corpuscle now breaks open, and each young parasite attacks another red corpuscle to repeat the process. If, however, an *Anopeles* mosquito bites the infected host, some malaria parasites are taken into the mosquito's stomach, and in this location they reproduce sexually to produce many small offspring. After this has occurred, the mosquito is infective, and is ready to transmit the disease to another human host.
14. The human body is like a small community in that it harbors large numbers of microorganisms. These microorganisms are on the body surface, in the digestive canal, and in various tissues. Some of them are parasites, but others are not.
15. The skin provides a surface barrier that keeps a great many small parasites from entering the body tissues. In the digestive canal, hydrochloric acid kills some invaders, and others cannot compete with microorganisms that are normally resident in the intestines.
16. Antibodies are substances in blood plasma that combat invading microparasites or the toxins that microparasites produce. Antibodies act only against specific parasites, and they do their work in various ways.
17. A vaccine acts as an antigen, and a corresponding antibody is produced by the human body. This antibody, in one way or another, defends against the development of an active infection.
18. When your own body forms the antibodies you have developed active immunity. When you receive the antibodies from the blood serum of another person or laboratory animal, you have passive immunity.
19. The organism of tetanus is an anaerobe. It cannot prosper and multiply in shallow wounds because it comes in contact with too much oxygen. It does prosper in puncture-type wounds from

which oxygen is largely excluded.

20. Tetanus toxoid—a vaccine—can be used to immunize an individual against the disease. If disease symptoms have already appeared, tetanus antitoxin can be used to provide passive immunity.
21. People vary in their immunities largely because a given person has developed antibodies against some diseases, but not against others, and the degree to which these antibodies are present depends upon various factors including the passage of time. Also, some immunities are more lasting than others.

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CHAPTER 17 The Public Health

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	The average person now lives much longer than he did a century ago, and various germ diseases have become much less common in the modern world. The major causes of death today are the heart-kidney diseases and cancer. We have continuing problems of immunization, pure food supplies, garbage disposal, and sewage disposal.	
2. Functional Diseases	Some heart diseases are of germ origin, but others are functional. In a functional disease some structure operates improperly. Functional diseases account for a large proportion of deaths today.	Microorganisms in Foods (p. 385) Things To Do, #1, 2, and 3 (p. 401)
3. Pure Food and Water Supplies		
A. Pure Food and Drug Act	This act serves to safeguard the purity and acceptability of food and drug supplies.	
B. Food poisoning	One general type is caused by paratyphoid organisms, another by ptomaines, and the most dangerous by the organism that causes botulism.	
C. Food supplies	We pasteurize milk to kill dangerous organisms that may be present. Milk from diseased cattle may contain the germs of tuberculosis and undulant fever. There are also many ways in which milk and other foods may be contaminated.	
D. Water supplies	The water we use comes	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	from various sources. Its purity must be safeguarded. Water is filtered, allowed to settle, sprayed up into the air, and treated chemically.	
4. Sewage and Stream Pollution	Many germs are present in sewage, and sewage can contaminate the waters of streams.	
5. Garbage Disposal	Garbage dumps that are not properly maintained become centers for the multiplication of pest organisms. Both garbage and sewage can be dealt with safely in modern disposal plants.	
6. Insect and Rodent Control		
A. Mosquitoes	Mosquitoes lay their eggs in floating masses on the water surface. Their larvae and pupae live in the water. The adults are winged and take to the air.	
B. Mosquito control	Drainage of ponds and marshes, and chemical treatment of the water can be used to control mosquitoes. But both methods have drawbacks and limitations.	
C. Houseflies	Houseflies cannot bite, and must subsist on liquid foods. They almost always lay their eggs on horse manure, and their larvae and pupae develop in manure piles.	
D. Rats and mice	The house mouse and the house rat are introduced species. They infest cities and rural areas. They destroy many materials, and are associated with the spread of various diseases.	
E. Control of rats and mice	Rats and mice are destroyed by various hawks, owls, and snakes. We some-	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	times kill them by using poison baits and gases.	
7. Drug Defenses	A satisfactory drug is one that will defend against the invading parasite, but not injure the host.	
A. Antiseptics	Antiseptics are substances that will kill germs or slow down their growth but are too toxic for use except on the outer surface of the body.	Antiseptics and Bacteria (p. 394) Things To Do, #4, 5, 6, and 7 (p. 401)
B. The sulfa drugs	Sulfa drugs are synthetic substances that serve to combat many bacteria of the coccus type.	
C. Immune strains	Some types of germs have developed immunity to certain drugs as a result of natural selection.	
D. Antibiotics	The first modern antibiotic was discovered by Dr. Alexander Fleming in 1928: it was penicillin. Various other antibiotics have been developed since that time. Antibiotics are effective defenses against a variety of germs, including many bacteria.	
E. Quinine	Quinine comes from the bark of cinchona trees that are native to South America, but are now cultivated in the East Indies. Quinine is used to combat malaria, but several synthetic drugs now serve the same purpose.	
F. Other new drugs	New drugs to combat tuberculosis and leprosy have been developed in recent years.	
8. Heart Diseases and Cancer	Germs cause some heart diseases, but many of these diseases are functional. The normal heart has reserve strength, but this may be	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	exhausted so that the heart fails. Hardened arteries may rupture and the result is paralysis or death.	
A. Tumors and cancers	Tumors are overgrowths of cells. A benign tumor is limited in its growth, but a malignant tumor or cancer keeps on growing. Some types of tumors appear to be caused by viruses, but other types do not.	
9. Alcohol, Tobacco and Narcotics		
A. Tobacco	Tobacco contains nicotine, which is toxic. Some studies have shown that heavy smokers have shorter lives than moderate smokers or nonsmokers; also, that cigarette smokers develop more cases of lung cancer than people who do not use cigarettes.	
B. Alcohol	Alcohol is a depressant, and it slows down reaction time. Normal reaction time is very important in the case of people who drive cars.	
C. Narcotic drugs	Narcotic drugs include heroin, opium, morphine, and cocaine. They are habit forming, and their continued use leads to physical breakdown and death.	

RELATED FILMS

	Min.		
Community Health in Action	22	Color	IFB
Finding Out About the Water Cycle	13	Color	UW
Ground Water	11	B&W	EBF
Man's Problem	19	Color	EBF
The Cycle of the Mosquito	12	B&W	McGraw
The Story of Milk	27	B&W	Bray
Wise Use of Water Resources	13	B&W Color	UW

OVERVIEW AND RATIONALE

The public health is far better safeguarded today than it was even a century ago. Diseases that once took a fearful toll are now held in check. Factors that have influenced public health include better nutrition, immunization, and the availability of modern drugs. Functional diseases have replaced germ diseases as the greatest threats to human life.

But we have continuing health problems of immunization, providing pure food and water supplies, and disposing of sewage and garbage in a safe manner. Foods and drugs are safeguarded by the provisions of the Pure Food and Drug Act. But even when national and local regulations are in operation, careless handling of foods and beverages can lead to contamination. Food poisoning is of several types, including the poisoning caused by paratyphoid organisms, ptomaine poisoning, and botulism. Milk supplies must be protected against the possibility that they have come from animals infected with tuberculosis or undulant fever, and also the possibility that they have been contaminated subsequent to production.

Our urban water supplies are drawn from various sources, and generally require special treatment to render them safe and acceptable. Filtration, settling, aeration, and chemical treatment are variously employed as dictated by local circumstances.

Sewage and garbage disposal are problems in some communities. Raw sewage and factory wastes pollute streams and create public health problems. Untended garbage dumps become breeding places for pests, including animals involved in the dissemination of diseases. The control of insects and rodents, and especially mosquitoes, houseflies, house rats and house mice is intimately related to maintaining a high level of public health.

When other defenses fail we depend on drugs to halt the attacks of many germs. Various antiseptics are used to eliminate skin infections, but these substances are too toxic to serve as internal medicines. During the present century two new groups of drugs, the sulfa drugs and the antibiotics, have been added to our defenses and have strengthened them greatly. We also have new drugs of other types to combat the organisms of tuberculosis, malaria, and leprosy. But germs sometimes develop immune strains, and our defenses against some parasites are not as good as we might desire. So the search for new drug substances continues.

Heart-kidney diseases and cancer are the principal causes of death in the United States today. People are living longer, and as a result functional diseases have become an increasing problem. Other health problems of growing concern include the dangers of smoking, drinking alcohol, and drug addiction.

GETTING STARTED

This chapter is not introductory, but a continuation of a topic that was partially developed in Chapter 16. It begins with the fact that many germ diseases were prominent causes of death a century ago, but now are largely under control. Included among them are the so-called childhood diseases such as diphtheria, measles, scarlet fever, and whooping cough. You can use a discussion of this advance in public health protection to introduce today's challenging public health problems.

Having studied Chapter 16, students should appreciate the importance of pure foods and beverages. The experiences provided in the experiments on food decay (page 385) should reinforce their recognition that contaminated and partially decayed foods are likely to be dangerous. Be sure the students realize that no matter how innocent the sources of foods and liquids may be, contamination due to careless handling is always a threat.

In dealing with pure water supplies you will need to make the point that the degree and type of treatment required depends somewhat upon the water source. If the water comes from a contaminated stream, the destruction of germs in it may be a primary consideration, but if it comes from a deep well it may be largely germ free, but so "hard" or full of mineral compounds that some special treatment is necessary. Each community is likely to have some special water supply problems, and the ways in which they are met can be very revealing. So can the study of sewage and garbage disposal in the community.

The subject of insect and rodent control is an important phase of public health provisions. Students should not have the belief that pest control is simple, easy, and inexpensive. In fact, the reverse is sometimes the case. Students should also realize and appreciate the importance of biological controls in reducing the numbers of pest organisms.

You can introduce the subject of chemical (drug) control by doing the experiment that appears on page 394. Be sure that the students understand that antiseptics are for external use only. Point out that drugs used internally are limited by the fact that they must be largely nontoxic. Some of the students may require help in understanding how a strain of microbes may become immune to a given drug.

More people are living longer today, and this may be a reason why heart-kidney diseases and cancer have become common afflictions. Be sure to make the point that a cancer is a tumor that is not limited in its growth, and that bits of cancer tissue can break free from their places of origin and become established in other parts of the body.

Many people have the idea (which was once held by some doctors) that alcohol is a stimulant when used in moderate doses. Actually, alcohol is a depressant in any dosage, and this is why it has an undesirable effect upon reaction time. The dangers of narcotic drugs are well known, and can hardly be overemphasized. They must be made clear to young people, including the fact that smoking "reefers" can easily lead to far more dangerous habits.

CLASS NOTES

Pure Food and Water Supplies (page 382) Paratyphoid organisms are responsible for many cases of food poisoning. Such organisms belong to the bacterial genus *Salmonella*. Attacks vary greatly in severity, some of them being fatal, and others producing rather mild symptoms. Thorough cooking will eliminate the dangers of *Salmonella* infections.

Ptomaines are chemical substances that form when certain proteins decay. Bacteria are, of course, a part of the story, because they are responsible for the decay. The term "ptomaine poisoning," however, has been used loosely, and is sometimes applied to any poisoning that results from eating spoiled meat or shellfish.

Botulism is caused by the toxin of the bacterial genus *Clostridium*, which is anaerobic. Botulinus toxin, in pure form, is one of the most poisonous substances known, and attacks of botulism can easily be fatal. Outbreaks are sporadic, and are generally traceable to some improperly canned or preserved food.

Tuberculosis can be contracted from infected cattle, by contact or near contact, and by drinking their unpasteurized milk. The non-pulmonary tubercular infections in man may involve the lymph glands, joints, bones, kidneys, intestines, and nervous system.

Undulant fever, which is also known as brucellosis, is due to borderline organisms of the genus *Brucella*. It can be contracted from infected animals by contact or near contact, and by drinking their unpasteurized milk.

Insect and Rodent Control (page 387) On a limited scale it is possible to keep mosquitoes from breeding in a pool by pouring oil on the water surface. The oil forms a thin film on the surface and prevents young mosquitoes from obtaining oxygen. It is also possible to add poisonous chemicals to the water, but these chemicals will kill other small organisms you may wish to preserve. Certain fish aid in control by feeding upon mosquito larvae.

To the uninitiated, various two-winged flies look very much alike, so they confuse other species with the housefly. One common type that looks a lot like the housefly is the stable fly, which has the piercing type of mouth parts and can "bite" viciously. Houseflies breed in moist horse manure, but other related flies deposit their eggs on a variety of decaying substances.

The introduced house rat and house mouse are not the only rodents that require control for one reason or another. There are many native species of mice in North America, and some of them are serious pests because of their attacks upon crop plants.

Drug Defenses (page 390) The sulfa drugs are coal tar compounds, and during the past 35 years hundreds of different sulfas have been produced and tested on disease control in laboratory animals. As might be expected, some of them have proved too toxic to be acceptable for human use. Others, however, have been found to be largely nontoxic and suitable as internal medicines. Sulfa drugs have proved to be most effective against bacteria of the coccus type; they are ineffective against some other bacteria, many of the borderline organisms, and viruses.

Immune Strains of Germs (page 392) The development of a strain immune to a given drug appears to depend upon two possibilities: a) because of individual variation some members of the original germ population may be immune, and b) a mutation that produces immune individuals may occur through chance. If the germ population remains in contact with the drug, the proportion of immune individuals in that population will increase due to the action of selection. That is, the naturally immune individuals will be more likely to survive the effects of the drug, and therefore will be the ones that are able to reproduce and pass the immunity on to their offspring. In time, the population may become largely resistant.

It is interesting to note that antibiotics actually came into use as germ killers in the closing years of the nineteenth century. In 1896, for instance, a substance called mycophenolic acid was obtained from a *Penicillium* mold and used to destroy anthrax bacilli. Three years later another microbial extract named pyocyanase was used temporarily. But at this time the potential of the antibiotics was not generally recognized, and their use was largely abandoned. This left the way open for Dr. Alexander Fleming to "rediscover" them. Initially all antibiotics have been derived from mold or bacterial cultures. The next logical step is to determine their chemical composition, and then devise ways and means of synthesizing them. Such steps have been followed through in the case of some antibiotics, but in some other cases the synthetic production either has not been achieved, or has proved to be more expensive than production by culturing and extracting.

Like the sulfas, antibiotics are not effective against all of the microparasites that assail us, but some of them, commonly known as broad-spectrum antibiotics, serve to control a fairly diverse group of microbes. We could use some new drug discoveries, and especially so if they proved effective against certain of our protozoan and viral parasites.

Just how and where European explorers of South America came upon cinchona bark is not known, although a number of different accounts have appeared in the literature. But we do know that "Jesuits powder," which was ground up cinchona bark, made its appearance in seventeenth century Europe. For a time the use of cinchona bark was rejected by many Europeans, who in a like fashion called tomatoes "love apples," and claimed that they were poisonous. But in time cinchona bark and the quinine that was extracted from it came into general use. For many years it was the only real defense against malaria organisms, and malaria was a prevalent disease in southern Europe.

Alcohol, Tobacco, and Narcotics (page 396) For a time during the past century various doctors held that alcohol was a stimulant when taken in small doses. More recent studies of its physiological effects make it evident that it is a depressant in any dosage. The old misconception continues to persist, however, in the minds of some laymen. No doubt they are deceived by the fact that a person who has consumed a couple of drinks may begin to feel light-headed. Actually, this is due to the fact that this person's cerebral centers that normally exercise restraints on frivolous behavior have been partially blocked by the depressant effect of alcohol.

LABORATORY SUGGESTIONS

Some Observations of Food Decay (page 385, one period for preparation)

Materials: 6 test tubes per group, ground meat, salt, sugar, a spice, vinegar, cotton.

This experiment relates to various ways in which we protect foods against molds and the bacteria of decay. Salt, sugar, spices, and vinegar are variously used in food-preserving media today. So are the practices of drying out (dehydrating) foods, and keeping them at low temperature or even in a frozen condition.

You could, of course, do this same experiment keeping all six of the test tubes and their contents under refrigeration. Over the same length of time you might expect to get somewhat different results, especially in the case of Tube 1.

ANALYSIS QUESTIONS (page 385)

1. Answers will vary. However, decay should proceed rapidly in Tube 1, and be variously retarded in the other tubes. Salting, drying, and the vinegar treatment may prove to be fairly effective.
2. Answers will vary. Bacterial spores may have reached the meat through the air, from a contaminated container, or in handling.
3. Answers will vary. The obvious one is to keep the meat at low temperature. Various forms of radiation might also be used.

Preventing the Growth of Decay Bacteria (page 394, one period for preparation

Materials: 6 test tubes per group, bean seeds, alcohol, mercurochrome, mouth wash, hydrogen peroxide, iodine solution, cotton, pipette.

Use the same amount of antiseptic solution in Tubes 3, 4, 5, and 6. Interested students may wish to examine a drop of material from Tube 1; it should exhibit the presence of many decay bacteria at the end of the experiment.

ANALYSIS QUESTIONS (page 394)

1. Answers will vary, but should be generally affirmative in both cases.
2. Answers will vary, but some differences should be evident.
3. If the bacteria do not grow, they do not reproduce. Hence, they do not become numerous, and meanwhile they may be destroyed by the body's natural defenses.

WORD MEANINGS (page 398)

1. pasteurized—heated enough to kill dangerous germs.
2. morphine—a narcotic derived from opium.
3. nicotine—poisonous compound found in tobacco.
4. antiseptic—substance used to kill germs on the body surface.
5. marijuana—a drug derived from hemp plants.
6. botulism—a type of food poisoning.

7. ptomaines—products of protein decay that cause food poisoning.
8. tumor—any overgrowth of cells in a tissue.
9. synthetic drug—drug made from chemical substances in the laboratory.
10. antibiotic—drug extracted from a mold or bacterium.

1. A fuctional disease is one that (*b*) is due to inefficient working of some body part.
2. A group of paratyphoid organisms cause numerous cases of (*b*) food poisoning.
3. A cancer is best described as a (*c*) tumor that keeps on growing.
4. A disease that has often been treated by using the drug quinine is (*d*) malaria.
5. Heroin is (*a*) a habit-forming narcotic.

SELF TEST (page 399)

1. True
2. False. Neither of these diseases is a common cause of death in the United States today.
3. False. Pneumonia is a germ disease that is usually caused by various cocci.
4. True
5. False. It can still be easily contaminated after pasteurization.
6. True
7. False. Ordinary raw sewage contains many germs.
8. True
9. False. Most mosquitoes lay their eggs on the surface of the water.
10. False. Draining a marsh may prove to be too costly in that there may be crop failures from lack of moisture, and the mosquitoes may return to the pools in the drainage ditches.
11. True
12. False. A housefly is unable to "bite."
13. True
14. True
15. True
16. False. They are likely to be among the first arteries to harden.
17. True
18. False. Cancer is usually not painful in the early stages.
19. False. Data collected indicates that nonsmokers live longer than heavy smokers.
20. True
21. True
22. False. Withdrawal symptoms are almost always very painful.

DISCUSSION QUESTIONS (page 400)

1. More people are protected by a) conferred immunities, and b) modern drugs. Better nutrition, control of sewage, and control of pests have also made a contribution.
2. The majority of deaths are caused by heart-kidney diseases and cancer.
3. A functional disease is not due to the presence of germs at the time of its occurrence. An infection is due to the presence of germs.
4. The three types discussed in the text are a) poisoning by paratyphoid organisms, b) botulinus poisoning, and c) ptomaine poisoning. They are, of course, caused by different organisms. In a) and b) the ill-effects are due to toxins the organisms excrete. In c) the effects are due to the formation of toxic protein decay products.
5. Germs of tuberculosis and undulant fever will be in the milk of cattle that have these diseases. In man, these germs can produce non-pulmonary tubercular infections and active cases of undulant fever.
6. Pasteurizing is accomplished by heating a substance enough to kill dangerous germs, but not enough to change its nature and taste materially. Several procedures are in common use; one is to raise the temperature to 165° F for one minute.
7. This varies, depending upon the source of the water. But generally the water is settled in basins, filtered, treated chemically, and deodorized by spraying it up into the air.

8. Streams polluted by sewage are a potential source of infection for man and his domesticated animals.
9. Carelessly maintained garbage dumps become the breeding grounds of rats, mice, flies, and other pests.
10. Useful chemical substances are extracted from the materials processed. The residues are not discharged until they have been rendered harmless.
11. Malaria and yellow fever are transmitted to man when he is bitten by infective mosquitoes.
12. A marsh that has been drained is no longer a breeding ground for mosquitoes. Extensive draining of marshes, however, may have an undesirable effect upon the water table. Also, drainage canals must be kept sediment-free, or pools of water will soon collect again.
13. In various areas mosquito populations that have been subjected to the DDT treatment have developed a partial immunity to this insecticide.
14. The easy and effective way to reduce the housefly population is to get rid of the horse manure piles in which they breed.
15. House rats and house mice destroy foods and many other materials. They are also reservoirs of various human diseases.
16. Antiseptics are chemical substances used to kill or slow the growth of germs on the skin surface. They are too toxic to be employed as internal medicines.
17. Sulfa drugs are synthetic compounds. They are effective against various bacteria which are mainly cocci.
18. In every germ population there are likely to be some individuals that are partially immune to a given drug. When the germs encounter this drug the non-immune individuals are killed, while the partially immune individuals survive to produce future generations. Because of this selective process the drug may lose its effectiveness as the germ population becomes increasingly immune.
19. A given drug may lose its potency because the germ it once controlled develops an immune strain. Also, some human individuals may prove to be allergic to the drug, but able to take another drug with safety and comfort.
20. Penicillin was discovered when Dr. Alexander Fleming noticed that a mold growth appeared to be killing bacteria in one of his cultures.
21. Most of the antibiotics we use today come from mold cultures, but some come from bacterial cultures, and a few are synthesized.
22. A synthetic drug is made from chemical compounds in the laboratory.
23. The bark of cinchona trees contains quinine, and for many years quinine was the only antimalarial drug.
24. There are various types of heart and circulatory diseases. When the circulatory system begins to fail the kidneys often are among the first organs to show adverse effects. Many deaths are due to a combination of circulatory and kidney failure.
25. A simple tumor is limited in its growth; a malignant tumor (or cancer) keeps on growing.
26. The presence of cancer may be indicated by sudden and unexplained weight loss, bleeding from a body opening, a chronic indigestion, a sore that does not heal, or the development of a lumplike growth.
27. Because alcohol taken in any dosage slows down reaction time. The driver becomes less able to react effectively in critical situations.
28. People who begin to use marijuana frequently "graduate" to the heroin habit after a period of time.

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BLOCK III Laboratory Investigations

THE CHAPTER AT A GLANCE

ACTIVITY	PURPOSE	RELATED CHAPTERS
1. A Change in Muscle Activity (p. 403)	To test the extent to which fatigue affects muscle activity	Chapter 12
2. Exercise and Heart Beat Rate (p. 404)	To test the effect of exercise on heart beat rate	Chapter 12
3. The Digestive System of a Frog (p. 405)	To become familiar with the structures of the vertebrate digestive system	Chapter 13
4. Starch Digesting Enzymes (p. 406)	To observe the effects of starch digesting enzymes	Chapter 13
5. Investigating the Effect of Certain Factors on Vitamin C (p. 407)	To test the effects of freezing and boiling on vitamin C	Chapter 13
6. Bromthymol Blue as an Indicator of Carbon Dioxide (p. 408)	To study carbon dioxide discharge by various organisms	Chapter 14
7. Investigating Carbon Dioxide Production From Yeast Cells (p. 409)	To investigate carbon dioxide production as indicative of the rate of yeast cell metabolism	Chapter 14
8. Investigating the Effect of Certain Factors on Behavior (p. 410)	To compare responses that are voluntary with responses that are mechanical	Chapter 15
9. Investigating Conditioning in Animals (p. 410)	To experiment with the conditioning of a small fish	Chapter 15
10. The Effect of Learning on Behavior (p. 411)	To investigate the effect of word associations	Chapter 15
11. Problem Solving by Trial and Error (p. 412)	To investigate detour and maze problems, and their solutions	Chapter 15
12. Factors That Affect Memory (p. 413)	To compare the learning of nonsense syllables with learning of familiar words	Chapter 15

ACTIVITY	PURPOSE	RELATED CHAPTERS
13. Testing for the Presence of Bacteria and Fungi (p. 414)	Learning to make culture plates, and testing for the presence of bacteria and fungi in the environment	Chapters 16 and 17

RELATED FILMS

	Min.		
Bacteria—Friend and Foe	11	B&W	EBF
Bacteria—Laboratory Study	15	Color	IU
Behavior in Animals and Plants	11	Color	COR
Circulation	17	B&W Color	UW
Digestion (Chemical)	19	B&W Color	UW
Digestion (Mechanical)	17	B&W Color	UW
Fungi	15	Color	EBF
Heart and Circulation	10	B&W	EBF
Louis Pasteur: Man of Science	30	B&W	Sterling
The Blood	16	B&W Color	EBF
The Human Body: Nutrition and Metabolism	13	B&W Color	COR
The Human Body: Skeleton	11	B&W Color	COR

OVERVIEW AND RATIONALE

This block of laboratory experiences is designed to reveal ways in which the human body responds to changes that take place in both its internal and its external environment. Included are studies of muscle activities, the effect of exercise upon the circulatory system, the action of digestive enzymes, carbon dioxide production under varying conditions, voluntary and involuntary responses, conditioning, learning processes, and the presence of microparasites in the environment.

These experiments and investigations also provide opportunities to become familiar with certain key techniques of biological procedure, including the interpretation of data, dissection procedures, the use of indophenol as an indicator, the use of bromthymol blue as an indicator, the conditioning of behavior, the use of nonsense syllables in tests of learning, and the preparation of culture media.

Experiences resulting from these investigations should provide students with more adequate concepts of how the various organs and systems of the body function, and how their functioning is presided over and coordinated by the body controls. Students should also become aware that many responses are wholly or largely automatic, and that others are wholly or largely mediated by the central nervous system.

LABORATORY SUGGESTIONS

A Change in Muscle Activity (page 403, one period)

Materials: watch or clock with second hand, a partner to work with.

Through continued and rapid use, muscle cells become fatigued. The internal environment of the cells, however, soon becomes normal again if a period for rest and chemical stabilization intervenes between periods of work. Actually, it is rather remarkable that muscle cells can "keep on going" as well as they do.

ANALYSIS QUESTIONS (page 404)

1. Answers will vary, but in general the absence of a rest period will lead to a condition in which muscular contraction will slow down progressively, and it will become harder and harder to maintain it.
2. In the exercises without rest, supplies of *ATP* probably were reduced and carbon dioxide waste accumulated. In the exercises with rest, time was provided for *ATP* to form again, and for carbon dioxide to be carried away by the blood stream.
3. You might try the same experiment while the arm is wrapped in a heating pad, or while the arm is submerged in a pan of cold water. It should be remembered, however, that man is a warm-blooded organism, and as such, his internal temperature is not greatly affected by external temperature changes.

Exercise and Heart Beat Rate (page 405, one period)

Materials: watch or clock with second hand.

Even mild exercise will increase the heart beat rate, and this is an entirely normal circumstance. In some individuals, however, it will be increased much more than in others. Also, in some individuals it will take longer for the heart beat to return to normal. These are further examples of the many individual differences that exist among individuals.

An occasional student may find difficulty in locating his pulse in the wrist area. Sometimes this student may be able to detect the pulsing of the carotid artery in his neck, on either side of the voice box or larynx.

ANALYSIS QUESTIONS (page 405)

1. Yes, the heart responds to the increased muscular demand by increasing its rate of contraction.
2. Answers will vary. During this period the blood was removing wastes from the muscle cells, and bringing them new supplies of glucose.
3. Answers will vary, but if the exercise was strenuous, body responses probably will include an increased breathing rate, sweating, muscular fatigue, and "a desire to rest."
4. The "sensing" of internal changes is a chemical phenomenon. Thus, an increase of carbon dioxide in the blood will stimulate the respiratory center in the medulla oblongata to speed up the breathing motions.

The Digestive System of a Frog (page 405, one period)

Materials: preserved frog, dissection tray, scalpel, scissors, forceps, dissection needle.

The body cavity of a frog is not divided into a thorax and an abdomen by a diaphragm. A frog has almost no esophagus, It has a three chambered heart, and long ribbonlike kidneys. But in general its digestive system includes the same organs that are found in a bird or a mammal, and the system as a whole accomplishes the same functions.

After performing the frog dissection it may be quite worth while to compare the frog's digestive organs with those of man. Certain differences as well as definite similarities will be evident.

ANALYSIS QUESTIONS (page 406)

1. Student descriptions of digestive organs will vary.
2. The stomach is a pouchlike organ that serves as a receptacle for food a frog may capture. The intestine is a longer tube in which the foods are acted upon by enzymes, and the digested materials may be absorbed.
3. Answers will vary. However, blood vessels are visibly connected with both the small and large intestine.

Starch Digesting Enzymes (page 406, one period)

Materials: 6 test tubes per group, Bunsen burner, ring stand, starch, hydrochloric acid, graduate, frog pancreas, Fehling's solutions A and B.

Human saliva contains a starch-splitting enzyme, ptyalin, which goes along with the food into the stomach, where it continues to act until it has been neutralized by contact with the hydrochloric acid of gastric juice.

The frog pancreas, like that of man, secretes a starch-splitting enzyme. This frog pancreas is a flattened, irregularly shaped organ, that lies adjacent to the stomach and the duodenum. Some students may need help in identifying the pancreas. The pancreatic duct discharges into the frog's duodenum, so the latter may be expected to contain a starch-splitting enzyme; in fact, it is probable that cells of a frog's duodenum produce a starch-splitting enzyme of their own.

ANALYSIS QUESTIONS (page 406)

1. Answers will vary. It is to be expected, however, that sugar will appear in Tubes 1, 5, and 6. In Tube 2 the ptyalin has been destroyed by heat, and in Tube 3 it has been neutralized by hydrochloric acid. Tube 4 contained no digestive enzyme.
2. The enzyme in human saliva is rendered inactive by boiling, or by contact with hydrochloric acid.
3. Answers will vary, but should be affirmative to both questions.
4. This could be done by carrying on the digestion in several test tubes at temperatures ranging from about 50° F to 100° F, and comparing the results. In each tube the quantity of starch suspension and enzyme material would have to be the same.

Investigating the Effect of Certain Factors on Vitamin C (page 407, one period)

Materials: vitamin C solution or tablets, indophenol, graduate, pipettes, small beakers or test tubes, bunsen burner, ring stand, test tube holder.

Vitamin C is one of the least stable of the vitamins and the purpose of this exercise is to demonstrate that it is affected by certain environmental changes.

Three to five milliliter test samples of the vitamin solution can be held in small test tubes. Several tubes can be heated at once by submerging them in a beaker of boiling water. Students may want to leave some tubes in the water longer than others to see what effect increased exposure to heat will produce. If time permits, have them try exposures of 10, 20, 30, and 40 minutes.

Similarly, small test samples can be frozen in test tubes by leaving them overnight in the freezing compartment of a refrigerator and then allowing them to thaw at room temperature the next day.

Indophenol is a poisonous chemical and students should be cautioned to avoid getting it on their skin. Be sure to adjust the vitamin C solution so that it takes at least 10 drops to turn the indophenol sample colorless.

Vitamin C is easily oxidized, and it may be possible to demonstrate a loss by exposure of some of the solution to air for a period of time. This vitamin also is sensitive to pH changes, and students may want to test the effect of an acid and a base. Have them add a few drops of concentrated hydrochloric acid or 10% potassium hydroxide to a vitamin sample and let it stand for 20 to 30 minutes. (Note: hydrochloric acid and potassium hydroxide are dangerous chemicals, and must be handled with great care.)

If fruit juices are available, you may want the students to use the indophenol test to determine the relative concentration of vitamin C in several kinds of juices. Have them find out how many drops of each juice it takes to decolorize an indophenol sample. They can test fresh and frozen juices as well as other beverages that may contain vitamin C.

ANALYSIS QUESTIONS (page 407)

1. Answers will vary, but the sample that was boiled should show the maximum loss of vitamin C, and the sample that was frozen should show the least loss.
2. In general, food should not be cooked, or left standing too long in air or water if vitamin C loss is to be prevented.
3. In the same manner as in these experiments, drops of various fruit juices could be added to indophenol solution to see which ones produce the most rapid color changes.

Bromthymol Blue as an Indicator of Carbon Dioxide (page 408, one period)

Materials: bromthymol blue solution, 10 test tubes and stoppers, soda straw, small aquatic animal, aquatic plant, bean seed, yeast suspension, glucose solution, test tube holder, Bunsen burner.

In this experiment the addition of carbon dioxide to the various tubes is as follows:

Tube 1: no addition since it is sealed
Tube 2: carbon dioxide added from exhaled breath
Tube 3: carbon dioxide discharged by the small animal
Tube 4: carbon dioxide produced by the aquatic plant, but also used by the aquatic plant in food making
Tube 5: carbon dioxide produced by the aquatic plant
Tube 6: carbon dioxide added to the contents from the air
Tube 7: bacteria of decay may add some carbon dioxide to the contents
Tube 8: yeast metabolism may add carbon dioxide to the contents
Tube 9: some yeast metabolism (but less than in Tube 8) may add carbon dioxide to the contents

ANALYSIS QUESTIONS (page 408)

1. Answers will vary, but the contents of Tubes 2, 3, 5, 7 and 8 should exhibit the presence of acid. The contents of Tubes 4, 6, and 9 may also show the presence of acid, but probably to a lesser degree.
2. You cannot be absolutely sure that acid reactions were due to carbon dioxide without specifically testing for the presence of this gas; this could be done by employing the limewater test.
3. In the case of the boiled bean you were testing carbon dioxide production by any bacteria of decay that happened to be present in Tube 7.
4. The results from Tube 6 indicate that carbon dioxide is present in the air.
5. The general conclusion is that respiration in various living things results in the production of the waste product carbon dioxide.

Investigating Carbon Dioxide Production From Yeast Cells (page 409, one period)

Materials: activated dry yeast, glucose, graduate, 2 large beakers, 5 small beakers, 5 small test tubes.

Since active yeast organisms and a food supply were present in all of the test tube-beakers, the only question is the rate at which the yeast organisms will produce carbon dioxide under the various conditions. The expectation is as follows:

Beaker 1: a steady rate of carbon dioxide production, since yeast plants are not foodmakers, and will carry on their metabolism either in light or darkness
Beaker 2: same as Beaker 1
Beaker 3: a lower rate of carbon dioxide production, because the low temperature slows down the rate of yeast metabolism
Beaker 4: the highest rate of carbon dioxide production, since the warm temperature favors a rapid rate of yeast metabolism

Beaker without sugar: no appreciable carbon dioxide production, because no food was provided for the yeast cells

ANALYSIS QUESTIONS (page 409)

1. The factors that favor carbon dioxide production by yeast cells are the presence of suitable food (glucose), and a favorable temperature.
2. In this experiment all of the tubes and beakers served as controls on the other tubes and beakers.
3. The observations were quantitative to the extent that accurate measurement of carbon dioxide production was made.
4. The chemical being tested could be added to a beaker of yeast-glucose suspension which would be kept in a dark, warm place. A similar beaker without the chemical and kept in the same place could serve as a control. Differences in the amounts of carbon dioxide produced in the two beakers would be related to the chemical's effect.

Investigating the Effect of Certain Factors on Behavior (page 410, one period)

Materials: notebook.

Some human actions, of course, are partially automatic or involuntary and partially voluntary. These are the cases in which higher control centers "take over" and modify what might otherwise be purely mechanical acts. Human responses, as a matter of fact, are likely to be of this type, because as the cerebral controls become more and more dominant in the higher vertebrates, the number of purely mechanical responses declines. So it is to be expected that most of the responses a student recalls will either be voluntary acts, or acts that are modified in some measure by voluntary controls.

ANALYSIS QUESTIONS (page 410)

1. All behavior is related in some way to either the internal environment or the external environment. Even purely voluntary acts concerned with learning or the creation of some product have some relationship to the environment of the individual.
2. Answers will vary, but most of the responses on the list undoubtedly had some relationship to previous experiences.
3. Habit plays an important role, especially in the ways in which responses are performed. Thus, one person runs or jumps in certain ways, and another person runs and jumps in other ways.

Investigating Conditioning in Animals (page 410, one period)

Materials: an aquarium with one or more fish.

In laboratory experiments, even earthworms have exhibited the results of conditioning to such factors in the external environment as electrical stimulation. Being considerably higher in the scale of evolutionary development, it is to be expected that fish will respond to conditioning influences.

ANALYSIS QUESTIONS (page 411)

1. The essential steps are to create a situation in which some automatic response, such as the response to the presence of the food stimulus is associated with some other stimulus.
2. Answers will vary, but the fact is that earthworms can be conditioned. The method of finding out, of course, involves doing appropriate experiments.
3. Practically every human being is conditioned in various ways by their previous experiences. Thus, one person may prefer to garden, while another would rather go fishing.

An Effect of Learning on Behavior (page 411, one period)

Materials: none.

Individuals are conditioned by many

events of the past. Thus, a person who has been in a house struck by lightning is likely to react to the words "thunder" and "lightning" in a negative way, whereas a person who has not had such an experience may be largely unmoved by these words. Since experience varies widely with time and place, considerable differences may be anticipated in the student responses to the word list used in this experiment.

ANALYSIS QUESTIONS (page 411)

1. Answers will vary. However, the words that provoke pleasant feelings are those the individual associates with pleasant experiences of the past.
2. Answers will vary. However, the words that provoke unpleasant feelings are those associated with unpleasant experiences of the past.
3. Symbols make up an important part of human experience. They are, for this reason, the "stock in trade" of the advertisers.
4. Response to a word or symbol is like conditioning in that the individual reacts to a new stimulus (the word symbol) in addition to the object or experience that the word or symbol represents.

Problem Solving by Trial and Error (page 412, one period)

Materials: piece of construction paper or light-weight cardboard, scalpel or knife, watch.

When you are limited to trial and error methods of solving problems, as many of the lower animals are, solutions are arrived at relatively slowly. When the same problem is repeated, however, human intelligence "takes a hand," and if the same problem is presented over and over, the time required for solution is likely to be progressively reduced.

ANALYSIS QUESTIONS (page 413)

1. The trial and error method serves to solve the problem, but in a first trial, a fairly long period of time may be required.
2. Answers will vary, but the expectation is that a considerable time may be required for solution of the problem. This is because memory provides limited aid in the first trial.
3. The attempt on the second day should result in a more rapid solution, because memory will supply a certain amount of guidance.
4. In the case of many common problems, memory can be called upon to give various clues as to probable solutions. We use these clues to form hypotheses or "best guesses" upon which we act.

Factors That Affect Memory (page 413, one period)

Materials: watch or clock, notebook.

The nonsense syllables on page 414 present letters in combinations that are unfamiliar. When you attempt to memorize a list of these nonsense syllables you can only depend upon past experiences to a very limited extent. For this reason, it takes some time to memorize List 1, and perhaps even longer to memorize List 2 because in this case distracting influences are at work. After memorizing List 2 it may prove difficult to recall List 1 accurately.

Lists 3 and 4 are very different, because the letters form words that are already familiar. Memory of past experiences with these words is now of considerable assistance. Learning time should be shorter than in the case of Lists 1 and 2. Also, learning time for List 4 may be the shortest of all, despite distracting influences, because the words in List 4 form a meaningful sentence.

ANALYSIS QUESTIONS (page 414)

1. Answers will vary, but the distracting influences may have delayed learning in the case of List 2.
2. Answers will vary, but it is probable

that the student will not be able to recall List 1 after memorizing List 2. Nonsense syllables have no meaning, and retention is likely to be brief.

3. List 4 is easy to memorize because the words form a sentence that evokes a mental picture of an event, and this type of mental picture is subject to rapid recall.
4. Attention is a very important factor when you attempt to memorize. Anything in the internal or external environment that causes attention to waver will slow up the process of memorization.

Testing For the Presence of Bacteria and Fungi (page 414, one period for preparation)

Materials: nutrient agar, 8 petri dishes and covers, bunsen burner, ring stand, deep pan, sterilization apparatus, tape, glass-marking pencil.

Growths of molds have a fuzzy appearance and are variously colored. Bacterial colonies adhere quite closely to the agar surface, and often look like small grey patches. Both types of colonies are likely to develop on any of the agar surfaces used in this experiment except the agar surface in Dish 1. Even a "clean" handkerchief will probably have mold and bacterial spores adhering to it.

ANALYSIS QUESTIONS (page 415)

1. The results of this experiment make it clear that microorganisms are abundant in our surroundings.
2. Dish 1 was left unopened after being sterilized so that spores from the air could not fall upon its agar surface. It served as a control, and if procedures were carried out properly, no mold or bacterial colonies appeared in this dish.
3. Microorganism colonies are similar in that they are made up of many small individuals closely packed together on the nutrient surface. They differ, however, in physical appearance, including form and color, and of course some of them are mold colonies, whereas others are bacterial colonies.

WORD MEANINGS (page 418)

A

1. bromthymol blue—a chemical that turns yellow in the presence of an acid.
2. fermentation—a process resulting in the formation of carbon dioxide and alcohol.
3. nutrient agar—material used to culture bacteria and fungi.
4. pulse—surge of blood passing through a blood vessel in the wrist.
5. small intestine—tube leading away from the stomach.
6. starch—a food substance that is changed to sugar by digestion.
7. sterilizing—method used to kill microorganisms.
8. trial and error—a method of problem solving.

B

1. carbon dioxide—a waste product of respiration.
2. colony—a group of cells growing tightly packed together.
3. enzyme—chemical that functions in protein digestion.
4. fat bodies—yellow fingerlike parts in the frog.
5. maze—a network of pathways.
6. saliva—liquid that contains a starch digesting substance.
7. spore—a special cell that resists drying.
8. yeasts—single-celled nongreen plants.

SELF TEST (page 419)

1. True. The filling of the stomach with food, for instance, will be followed by the contraction of muscles in the stomach wall.
2. False. If the internal environment becomes sufficiently unfavorable, death results.
3. False. Blood movement is essential to maintaining a favorable internal environment.

4. True
5. False. The liver is the largest organ in the frog.
6. True
7. False. The small intestine is joined to the stomach.
8. False. The pancreas lies between the stomach and the duodenum.
9. True. This is the pyloric valve.
10. False. The yellow fingerlike organs are the fat bodies.
11. True
12. False. Indophenol becomes colorless in the presence of vitamin C.
13. False. Energy is released from food molecules in respiration.
14. False. Bromthymol blue is used to determine whether a substance is acid or alkaline.
15. False. Yeast cells do not contain chlorophyll.
16. True
17. False. If the behavior pattern exists at birth it is not "learned."
18. False. Animals often will make a number of attempts before they solve the problem.
19. True
20. False. So far as we know the majority of microorganisms have no direct relationship to disease.
21. True. Decay is essential in that it completes natural cycles in which chemical substances are returned to air, soil, and water.

DISCUSSION QUESTIONS (page 420)

1. Before energy can be released from food in the animal body, the food must be digested, absorbed by the blood stream, and delivered to the cells of the various tissues.
2. The internal environment includes all of the things and conditions within the body tissues. Thus, the amount of protein waste within a given cell is a factor of its internal environment.
3. Factors that favor the survival of body cells are freedom from mechanical injury, and chemical conditions that constitute a favorable internal environment.
4. The pulse is a surge of blood caused by contraction of the left ventricle. Thus, there is one "pulse beat" for each heart cycle.
5. A frog has the same digestive organs that man possesses, and these organs perform similar functions. There are, however, various differences. In the frog, for instance, the esophagus is little more than an opening from the pharynx into the stomach, and the intestinal tract is relatively shorter and simpler.
6. Saliva has a mechanical function in that its presence makes it easier to swallow food. It also contains an enzyme (in man) which changes starches into sugars.
7. Respiration and fermentation are both processes in which various cells obtain energy from foods. In respiration, however, oxygen is used to initiate the chemical breakdown, which is not the case in fermentation.
8. The carbon dioxide is taken into blood plasma and carried to the lung tissues, where it is discharged when we exhale.
9. A chemical indicator is a substance used to detect the presence or absence of some other substance or some condition. Chemical indicators we have used include phenolphthalein, bromthymol blue, and indophenol.
10. Yeast cells look like various small types of animal cells, and like animal cells, they lack chlorophyll and thus depend upon an outside source for food chemicals. Their metabolism, however differs from that of typical animal cells.
11. Inborn behavior is inherited behavior that is ready to function when appropriate stimuli are presented. Thus, your stomach does not have to "learn" to secrete digestive fluid when food enters it from the esophagus. On the other hand, learned behavior requires experience for its development. For example, you learn how to read, to cook,

to sew, and a thousand other things.

12. We are conditioned by various events in the past that we associate either with pleasant or unpleasant experiences. So are many other animals. An example is the old saying that "the singed cat fears the fire."
13. Conditioning can be an advantage in that it causes us to avoid various situations that are potentially dangerous, but accept situations that are likely to yield satisfactory experiences. However, some conditioning is associated with habits that place the individual at a disadvantage. For instance, associated fears can be out of proportion to the potential dangers involved.
14. Adults have lived longer than children and have had a wider range of experiences. When a child is presented with a problem he may have no previous experiences that will help to provide a solution. An adult is more likely to have had such experiences. The main factors that operate in such situations are previous contact with similar problems, and the ability to recall.
15. Finding a path out of a maze is an example of problem solving by trial and error. No particular effort is made to form best guesses in advance, because there is no background of experience upon which to base these best guesses. On the other hand, problem solving by reasoning involves drawing upon experience for ways and means of finding a solution. In a very simple example, a man discovers that his roof is leaking when it rains. From experience, he recognizes that something is wrong, and that one or more shingles must be out of place. He observes just where the water is coming through and marks the place. Then he climbs up on the roof and inserts a few new shingles so as to stop the leak.
16. A young boy learning to catch a ball without benefit of any instruction may try various ways of doing this act, until he "hits upon a way" that seems to work. It does not follow that he has found the best way, but at least it is a way that "works" some of the time.
17. Reasoning depends upon the ability to delay response until the problem has been examined and the results of previous experience are brought to bear upon it. To do the latter, it is necessary for memory to function.
18. Various organisms other than man appear to be influenced by symbols. Thus, various higher animals emit cries that others of their kind interpret to mean the presence of food or the existence of danger. You have also read about the wagging dance and the round dance of honeybees, and how they are used to direct other honeybees to food. Certain of the higher animals such as various birds and mammals can be conditioned to respond to specific colors and to shapes such as triangles or circles.
19. You find that remembering things under certain environmental conditions is difficult. You also find that remembering things under other environmental conditions is fairly easy. The obvious thing to do is to seek the latter type of environmental conditions when there is any studying to be done.
20. The omnipresence of microorganisms is related to the fact that they are very small and easily transported, that they can live or survive under a wide range of conditions, and that when conditions are favorable to them, they can multiply very rapidly.
21. Spores are small, resistant cells, that can survive when conditions are too dry or otherwise unfavorable for full-sized active cells. But spores can soon become active cells if they encounter favorable conditions.
22. In general, the more microorganisms that enter a culture dish the more colonies, but there are certain limitations. Some microorganisms are "antagonistic" to others, and if enough microorganisms of any kind are present, they

may all be killed by the accumulation of their own wastes.

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BLOCK IV Production and Control

CHAPTER 18 Reproduction and Population

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Cell division is a basic process that provides new units for both growth and repair.	
2. Chromosomes and Genes	The cell nucleus contains structures known as chromosomes. Chromosomes, in turn, contain smaller units known as genes. In a given gene a small amount of DNA is combined with protein molecules.	
A. DNA and RNA	In the cell nucleus the DNA of a gene produces a corresponding type of RNA. This RNA passes out into the cell's cytoplasm and causes certain proteins to be formed. The DNA in the genes thus determines what heredity will be. There are many types of DNA and RNA.	
B. Chromosome pairs and numbers	In the adult body, chromosomes are in pairs; half from the male parent of the individual, and half from the female parent. The number of chromosomes is the same for all members of a species.	
C. Paired genes	Like the chromosomes which contain them, genes are in pairs.	
3. Mitosis	Mitosis is a type of cell division in which the chromosome material is divided equally between two daughter cells. Before this division occurs, each chromosome is replicated.	Things To Do, #1, and 2 (p. 438)
A. Results of mitosis	Mitosis produces new cells	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	for the growth and repair of tissues. It is also involved in the process of reproduction.	
4. Sex Cells		
A. The sex organs	Male sex organs are testes that produce sperm cells; female sex organs are ovaries that produce egg cells.	
B. Meiosis and the reduction division	Meiosis is the process in which male and female sex cells become mature. In one phase of this process a reduction division occurs, and the maturing sex cell is left with half of its normal number of chromosomes.	Things To Do, #3, 4, 5, and 6 (p. 438)
C. Fertilization	In fertilization, a mature sperm cell unites with a mature egg cell. Each of these cells brings half the normal number of chromosomes to this union. The result of the union is a fertilized egg cell that contains the normal number of chromosome pairs.	
D. Development	Development is the process in which a fertilized egg cell divides successively to produce an embryo that ultimately may develop into a new individual. The nature of this development varies greatly: apparently it depends upon the particular kinds of DNA that are in the fertilized egg cell.	
5. Populations	To maintain its normal population a species must have a successful method of reproduction. In many cases this is achieved by producing enormous numbers of spores, seeds, or eggs. Only a small percentage of the new individuals ever attain maturity.	Potential Population Increase (p. 434) Seeds of a Corn Plant (p. 434) Division of a Single-celled Organism (p. 434) Growth of a Yeast Population (p. 525) The Life Cycle of a Mold (p. 526)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
6. Parental Care	Various birds and mammals provide care for their young, and a larger percentage of these offspring survive. Such species generally produce limited numbers of offspring.	

RELATED FILMS

	Min.		
DNA : Molecule of Heredity	16	Color	EBF
From One Cell	14	Color	ACS
Life and Death of a Cell	20	Color	IFB
Meiosis.	12	Color	IFB
Meiosis: Sex Cell Formation	16	B&W Color	EBF
Mitosis	9	Color	IFB
Mitosis	24	Color	EBF

OVERVIEW AND RATIONALE

Chapter 18 introduces the subject of how organisms reproduce, and the potential effects of this process upon plant and animal populations. It is well known that in the past various populations have declined, and that many species have become extinct. To maintain normal species numbers, there must be an effective process of reproduction.

This chapter also includes discussion of genes and chromosomes, the presence and role of *DNA* in these structures, the nature of mitotic division, and the processes of sex cell maturation, fertilization, and development. Thus, it prepares the way for a study of hereditary mechanisms in man and other organisms.

The point is made that some species maintain their population by producing vast numbers of potential offspring, of which only a small percentage survive to become the adults of the next generation. Other species, including many birds and mammals, produce smaller numbers of offspring, but due to the fact that parental care is provided, enough new individuals survive to maintain these populations. In all cases, however, the death rate in early stages of the life cycle is high, and untold numbers of fertilized egg cells fail to produce new individuals.

GETTING STARTED

One way to begin the study of this block is to review facts and theories relating to the manner in which life on our earth has changed during the long period of geological time. You can use the Introduction to Block IV as a basis for such a discussion.

Then it may be desirable to begin the study of sex cells, chromosomes and genes, and mitosis, which can be introduced by examining an onion root tip section. Be sure that the students understand why chromosomes are found in pairs in an adult body, and why a primitive sex cell must undergo a reduction division before it can become mature and participate in fertilization. The *DNA-RNA* mechanism is also important, and especially so in its relationship to future studies of heredity.

The observation entitled *Seeds of a Corn Plant* on page 434 can be employed to initiate a discussion of potential and actual population increases. Students should be aware that only a very small percentage of spores, seeds, and eggs are destined to produce adults, for this concept is essential to understanding how selection operates in nature.

CLASS NOTES

Chromosomes and Genes (page 425) Chromosomes vary in size and shape, and at some stages in the life of a cell they may be all but invisible. Visible, stained chromosomes, however, generally have a banded appearance, and it is believed that the tiny genes are distributed along their long axes. A given chromosome may incorporate a great many genes, which are too small to be seen with the aid of any existing microscope.

The genes presumably are composed of nucleoprotein molecules, and it is the *DNA* components of these nucleoprotein molecules that are believed to be responsible for what the genes can do. There may be thousands of these genes in a single nucleus.

One kind of *RNA* is called "messenger *RNA*" because we think that it is the link between corresponding *DNA* in the nucleus and protein (including enzyme) synthesis in the cytoplasm. So far as we now know, *DNA* does not leave the nucleus of a cell, but is represented in the cytoplasm by the *RNA* it produces.

It has become increasingly evident from the results of recent research that *DNA* is not only the primary factor in heredity, but that *DNA* through its *RNA* is a controlling force in cell metabolism.

The basic units of a nucleic acid are substances called nucleotides. A nucleotide, in turn, is made up of a) either a purine or a pyrimidine unit, and b) a sugar and a phosphate. A given nucleic acid consists of hundreds of these nucleotides bonded together in a double spiral. One important point to remember is that since so many units are banded together in the nucleic acid molecule, vast numbers of different combinations may exist.

The sugar component of a nucleotide is either ribose or deoxyribose, with the deoxyribose unit containing one less oxygen atom than the ribose. *RNA* is made up of ribose nucleotides, and *DNA* contains only deoxyribose nucleotides.

Mitosis (page 427) This is the common type of division in all cells that have organized nuclei. Even an ameba exhibits a primitive type of mitotic division. One of the most important phases of this process is not visible and takes place before the actual splitting of the cell begins. This is the replication of the chromosomes, and presumably of the many genes they contain.

Thereafter four progressive stages in mitosis are ordinarily recognized: the prophase, the metaphase, the anaphase, and the telophase. These stages merge into one another, and once the process of division has begun, it is usually continuous.

Sex Cells (page 429) In the process of becoming mature, sex cells must be changed from cells that contain the diploid (2n) or normal number of chromosomes into cells that contain the haploid (n) number of chromosomes. This is not accomplished in the same manner in all cells: however, there are often two meiotic divisions of the chromosomes with only one replication, and the cells so-produced have the haploid (n) chromosome number. In the male all of these cells may go on and develop into mature sperms, but in the female only one descendant of the primordial sex cell becomes a mature egg cell. Mature egg cells are characteristically much larger than mature sperm cells.

Potential Population Increase (page 434) This is prodigious in the case of many plants and lower animals. The counter-balancing effect of a high death rate keeps the land areas and the seas from being rapidly overpopulated. In many species this death rate is very high indeed, and especially so in the early stages of their life cycles. Nature is by no means mild and beneficent; a very real struggle to survive goes on day and night.

LABORATORY SUGGESTIONS

Seeds of a Corn Plant (page 434, one period)

Materials: ear of corn, notebook.

Students probably will be astonished when they discover how many progeny a single corn plant can produce. They will be even more astonished when they attempt to compute the numbers of the progeny in the third generation.

Division of a Single-celled Organism (page 434, one period)

Materials: notebook.

This exercise is also one of projecting the potential population through a number of generations, but in this case the students deal with a single-celled organism. Nevertheless, the number of potential descendants after a 24-hour period is likely to be very surprising.

ANALYSIS QUESTIONS (page 435)

1. The corn plants would soon use up all of the available space for growth. The single-celled organisms would either exhaust available food supplies, or be killed by their accumulated wastes.
2. In general, unfavorable conditions of the environment keep organisms from realizing their enormous potential for increase. Such factors involve the availability of food, competition from other organisms, lack of sunlight in the case of green plants, and unfavorable soils, temperatures, and pressures.

WORD MEANINGS (page 435)

1. A chromosome is composed of (*b*) protein, *DNA* and *RNA* molecules.
2. Small hereditary units located in the chromosomes are known as (*c*) genes.
3. If a mature sex cell of species *A* contains four chromosomes, each body cell of species *A* will contain (*c*) eight chromosomes.
4. The units in a cell that determine what kinds of *RNA* molecules will be formed are the (*d*) *DNA* molecules.
5. When two cells divide so that each daughter cell receives a full set of chromosomes, the process is called (*c*) mitosis.
6. The process in which a nonmature sex cell becomes a mature sex cell is know as (*d*) meiosis.
7. Mature egg cells are formed from cells of (*a*) an ovary.
8. If the chromosome number of species *B* is 16, mature egg cells of this species will contain (*b*) eight chromosomes.
9. The union of a mature egg cell and a mature sperm cell is known as (*b*) fertilization.
10. Among the simpler animals, the vast majority of eggs (*c*) fail to produce new individuals.

SELF TEST (page 436)

1. True
2. True
3. False. *RNA* molecules are produced by *DNA* molecules.
4. False. *DNA* molecules are found in the nuclei of cells.
5. True
6. True
7. False. Except for occasional differences between the sexes, the number of chromosomes in body cells is the same in all members of a species.
8. True
9. False. Even an ameba exhibits a simple type of mitosis.
10. True
11. True
12. False. Egg cells are consistently larger than the corresponding sperm cells.
13. True
14. True
15. True
16. True
17. False. Only a small percentage of seeds give rise to new adult plants.
18. True
19. False. Simple animals usually have a higher potential rate of reproduction than mammals do.
20. True

DISCUSSION QUESTIONS (page 437)

1. In asexual reproduction the offspring has only one parent, as in the case of a new potato plant that grows from the tuber of another potato plant. In sexual reproduction a male and female sex cell unite to produce the new individual, as in the case of a new radish plant that has grown from a seed.
2. Genes are hereditary units that are located in the chromosomes.
3. Apparently the *DNA* molecules are the bearers of hereditary information. At the same time, they are the controlling factor in cell metabolism.
4. *DNA* molecules produce corresponding *RNA* molecules that pass into the cell cytoplasm and influence the nature of protein synthesis.
5. They are paired because half of them come from the individual's male parent and half from the individual's female parent.
6. The genes determine what heredity will be. Apparently the vital factors are the *DNA* portions of nucleoprotein molecules in the genes.
7. Muscle tissue is able to regenerate in many types of animals. This means that existing muscle cells must divide to produce new muscle cells. The division of these cells is mitotic. The same thing happens in the case of gland cells.
8. Meiosis is the process in which a primordial germ cell becomes a mature sex cell or gamete. An essential part of the process is the reduction division, in which the maturing cell loses half of its normal chromosome content.
9. A sperm cell penetrates the cell membrane of the egg cell. Then the sperm nucleus unites with the egg cell nucleus. Each of these nuclei brings the haploid number of chromosomes to this union, and as a result, the fertilized egg cell contains the diploid or normal number of chromosomes.
10. Most types of development are similar in that the individual begins life as a single cell: the fertilized egg cell. Repeated division of this egg cell is necessary to produce the cells of an embryo, and later on, an adult. In complex organisms you also find that all of them exhibit differentiation of structure and function among their cells as development proceeds.
11. If reproduction is not successful, the population begins to decline. If this trend continues, it leads to extinction. Many former plant and animal species have become extinct.
12. Many fertilized eggs fail to produce new individuals because their development is left largely to chance. Some fish, for example simply lay their eggs in the water and swim away. The eggs may be eaten by other aquatic animals, and so may the young fish that hatch from any eggs that may have escaped destruction.
13. When parental care is provided, the young are more or less protected against potential enemies, and in many cases are assured of a food supply. As a result, a fairly high percentage of the young are likely to survive.
14. If organisms reproduced at their full potential rate all communities would soon be so overpopulated that food supplies would be greatly diminished. Population explosions of certain species have actually occurred. Generally, they have been followed by mass starvation and the death of many individuals.

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CHAPTER 19 Plant Reproduction

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Single-celled plants reproduce by cell division, some plants reproduce by means of spores, and some plants reproduce by means of seeds. Some of the seed plants, however, can also be reproduced from parts of parent plants.	
2. Flowers, Seeds and Fruits	The seed plants bear flowers, which vary considerably in structure. A complete flower has sepals, petals, a pistil, and stamens. But some flowers lack one or more of these structures.	Study of Flower Parts (p. 446)
A. Pollen and pollination	Pollen grains are formed on the anthers of stamens. They contain cells that give rise to sperm nuclei. In pollination, these pollen grains are transferred to the stigmas of pistils. Some flowers are self-pollinated, and others are cross-pollinated. Some are pollinated by the wind, and others are pollinated by insects.	Pollen Grains (p. 447)
B. Fertilization	A pollen grain on a stigma develops into a pollen tube which contains sperm nuclei, and grows down through the style until it reaches an ovary. Then a sperm nucleus unites with an egg cell. This union is called fertilization.	Things To Do, #1 (p. 454)
C. Seed formation	The fertilized egg cell begins to divide and produces an embryo that is enclosed in a seed case together with stored food. This is the seed.	
D. Fruits	Among flowering plants, parts of ovaries often de-	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	velop into fruits that surround the seeds. Some fruits are hard, dry fruits, and others are fleshy fruits.	
E. Seed dissemination	Seeds are spread about by the wind, by animals, and sometimes by running water.	
3. Sprouting	When conditions for growth are favorable, the embryo in a seed begins to develop. As a result, the seed sprouts. Dicot plants have two seed leaves, and monocot plants have only one seed leaf.	Testing Seeds (p. 527) Investigating the Effect of Soaking on Seeds (p. 528) Seed Parts and Sprouting (p. 528)
4. Growth	Stored food in the seed provides for early growth. But if conditions are favorable the young plant is soon able to make its own foods.	Structure of a Lima Bean Seed (p. 449) ✓ Things To Do, #2, and 3 (p. 455)
5. Growth From Parts	Various higher plants can grow from parts, such as underground stems, roots, bulbs, runners, and shoots. This type of reproduction is asexual. Some plant hormones accelerate growth and others retard growth.	Things To Do, #4, 5, and 6 (pp. 454-455) ✓
6. Grafting	We use grafting techniques in raising various plants. A scion is grafted on a stock in such a manner that the cambium layers of the two parts are brought together.	Things To Do, #7, and 8 (p. 455)

RELATED FILMS

	Min.		
A Tree is Born	28	Color	USFS
Flowers and Their Purpose	12	Color	Cenco
Growth of Seeds	14	B&W Color	EBF
Gymnosperms	16	B&W Color	EBF
How Flowers Make Seeds	11	B&W Color	COR
Life Cycle of a Plant	11	B&W	UW
Reproduction in Plants	13	Color	COR
Seed Dispersal	14	B&W	UW
The Growth of Plants	12	B&W Color	EBF
The Seed of Plants	12	B&W Color	Cenco

OVERVIEW AND RATIONALE

Chapter 19 deals with reproduction in plants, with emphasis upon the higher plants that are so common in land communities. Many of these higher plants produce seeds, but also have an asexual method of reproduction, inasmuch as they can grow from parts such as stems, bulbs, and roots.

Flowers vary in structure, but many of them have both male and female parts. The male parts are the stamens and their anthers; the female parts are pistils that include stigmas, styles, and ovaries. Incomplete flowers lack various parts such as petals, stamens and pistils. Some flowers are grouped together to form large "heads" or blooms.

Cross pollination occurs in some species of plants, and others are self-pollinated. In pollination, a pollen grain must go from an anther to a stigma. In some cases, gravity supplies the necessary force for this transfer. Other plants are pollinated by the wind or by insects.

A pollen grain that has landed on the right kind of stigma soon develops a pollen tube that grows down through the style to reach an ovary. In the pollen tube is a sperm nucleus that unites with an egg cell of the ovary. The fertilized egg cell forms an embryo surrounded by a seed case: this is the seed, and it contains a certain amount of stored food.

Many flowering plants develop fruits around their seeds. The fruits are fleshy in some species, and dry and hard in others. Fruits often have a relationship to the ways in which seeds become scattered. Some fruits and their seeds are scattered by the wind, some are carried in streams, and others are transported by various animals.

Under favorable environmental conditions the embryo in a seed begins to develop and the seed sprouts. Stored food provides for early growth, but the new plant soon develops leaves and a root system, whereupon it is able to make foods in quantity.

Various flowering plants can be reproduced from parts, such as bulbs, roots, stems, runners, and shoots. We take advantage of this fact in raising some of our crop plants, and we also employ the related technique of grafting. Unfortunately, however, some of our worst weed pests can also grow from parts.

GETTING STARTED

Since this chapter is largely concerned with reproduction in the higher plants, a good way to begin the study is to carry out the observation of flower structures described on pages 446 and 447. In this observation the students deal with a complete flower, which has sepals, petals, stamens, and pistils, and they need to be advised that not all flowers are of this type. For instance, wind-pollinated flowers often have no petals, and in some plant species flowers are either staminate or pistillate.

Pollination is a fairly simple concept, and most students will grasp it readily. The growth of the pollen tube to reach the ovary, however, may require some explanation from the teacher. You will recognize, of course, that sperm nuclei and mature egg cells in an ovary both contain the haploid (n) number of chromosomes. After fertilization, the plant embryo develops as the primary structure within a seed.

The study of a sprouting bean seed described on page 447 may be used as you move on to the subject of seeds and sprouting. At this point it is a good idea to make the distinction between dicot plants (such as beans), and monocot plants (such as corn).

From these experiences it is fairly simple to progress on to the asexual types of reproduction in higher plants. Growth of plants from parts is important in human economy because we exploit it in producing a number of crop plants, and because the growth of weeds from parts poses special problems of control.

CLASS NOTES

Flowers, Seeds, and Fruits (page 440) Being wind-pollinated, many of the grass plants have incomplete flowers, which are not at all conspicuous, and would not be called "flowers" by the average person. The word "flower" may mean one thing to a scientist, and another thing to a nonscientist.

Flower structures vary among the many types of seed plants. In some flowers, for example, the style is absent, and the stigma is borne on the ovary. Some pistils are composed of more than one unit, and some flowers have more than one pistil. Petals may be absent, or joined together to form a continuous structure. Some flowers have only male sex parts, and other flowers have only female sex parts.

Gymnosperms as well as angiosperms are seed producers. Only the angiosperms or flowering plants, however, develop seed cases. The angiosperms are of two general types, which can be distinguished as follows:

The Monocots

A single seed leaf
Vascular bundles scattered throughout the stem
Leaves usually parallel-veined

The Dicots

Two seed leaves
A cambium layer separating two groups of vascular bundles
Leaves usually netted-veined

Some seeds can sprout while they are still on the parent plant; others require periods of days, months, or even years to attain sprouting status. After this status is attained, some seeds remain viable for only a few days, while others will still sprout after two centuries have passed.

Other factors being equal, sprouting depends upon the existence of favorable temperatures, and a suitable supply of water and oxygen. In most cases, the presence of light is not a requisite factor.

Some ovaries develop fleshy fruits, which are variously classified as berries, drupes, and pomes. Examples are as follows:

a) Berries: bananas, grapes, grapefruits, lemons, melons, oranges, squashes, and tomatoes.
b) Drupes: cherries, coconuts, peaches, plums, and walnuts.
c) Pomes: apples and pears.

Dry fruits are of two types: the dehiscent fruits that open at maturity, and the indehiscent fruits that remain closed. The former include fruits of beans, peas, peanuts, and poppies, while the latter include the fruits of grass plants, ash trees, chestnuts, hickories, maples, and oaks.

The foregoing types are simple fruits, and there are also aggregate fruits such as those produced by blackberry, raspberry and strawberry plants, and multiple fruits like the mulberries and pineapples.

Representative monocot plants are as follows: asparagus, barley, calla lilies, cattails, coconuts, corn, oats, onions, orchids, rye, and wheat. Representative dicot plants include apples, buttercups, carnations, celery, elms, melons, peaches, peas, plums, sunflowers, tomatoes, turnips, and willows.

Growth from Parts (page 449) These potatoes bloom and bear seeds at the end of their biennial life cycle. We raise them from pieces of tubers for the simple reason that this practice enables us to get a crop in one growing season, which is the second season of the normal life cycle. Incidentally, the white potato is native to the Americas, and was not known in the old world prior to the voyages of discovery.

LABORATORY SUGGESTIONS

Study of Flower Parts (page 446, one period)

Materials: any complete flower, forceps, razor blade, hand lens.

The particular flower available may contain more than one pistil, which may be confusing to the students unless the fact is called to their attention. Students may also be puzzled by their memories of large flower "heads," such as those borne by sunflowers. They will need to develop the concept of a lot of flowers packed together in one large "bloom" when they deal with members of the sunflower family.

ANALYSIS QUESTIONS (page 446)

1. Answers will vary. Certain flowers may or may not have some of the floral parts.
2. The stamens and their anthers are the male structures. The pistils (stigma, style, and ovary) are the female structures.
3. Generally speaking, flowers that are insect pollinated have well-developed and brightly colored petals.

Pollen Grains (page 447, one-half period)

Materials: flower or flowers, blank slides, cover glasses, microscope.

Most flowers have both stamens and pistils, and many of them are self-pollinated. A pollen grain develops into a pollen tube when it reaches the stigma of an appropriate flower. Near the tip of the developing pollen tube are two sperm nuclei. However, only one sperm nucleus unites with an egg cell in the ovary.

ANALYSIS QUESTIONS (page 447)

1. They were similar in shape, size, and texture if they came from the same species of flower, but perhaps quite dissimilar in form if they came from a number of different flowers.
2. The cells of the pollen grain produce the pollen tube.

Structures of a Lima Bean Seed (page 449, one period)

Materials: lima bean seeds, container, pins, hand lens.

The surprising thing about a bean seed is how much of it is composed of the two cotyledons. These cotyledons, or seed leaves, contain the stored food. The embryo proper, which gives rise to the upright stem and the root system, is a very small structure when sprouting begins.

ANALYSIS QUESTIONS (page 449)

1. The embryo of the bean plant consists of two seed leaves and a structure that produces the root system and the shoot system, the latter consisting of the stem and leaves.
2. The seed of a monocot plant has only one seed leaf.
3. The function of the seed coat is protective. Among other things, it prevents excessive drying.

WORD MEANINGS (page 452)

1. stamen—develops anther at its tip.
2. pistil—bears a stigma at its tip.
3. monocot—develops a single seed leaf.
4. scion—stem that is grafted on a stock.
5. tuber—fleshy enlargement of an underground stem.
6. ovary—develops mature egg cells.
7. pollen tube—contains sperm nuclei.

1. The structure which contains a plant embryo is a (*c*) seed.

2. The structure which is part of a pistil is a (*a*) style.
3. A plant fruit is developed from parts of (*d*) an ovary.
4. To a biologist, a pea pod with its enclosed seeds is a (*b*) fruit.
5. A flower which has no petals could properly be called (*b*) incomplete.
6. A young plant which has two seed leaves is a (*a*) dicot.
7. A pollen tube develops from a (*d*) pollen grain.

SELF TEST (page 452)

1. False. Spores are small and contain little stored food.
2. True
3. True
4. False. They develop at the upper ends of stamens.
5. False. Staminate flowers bear only male structures; pistillate flowers bear only female structures.
6. True
7. True
8. False. Pollen grains are developed on anthers.
9. False. The offending pollen comes from ragweed plants.
10. True
11. True
12. False. The fertilized egg will contain the diploid number: in this case, 12 chromosomes.
13. True
14. False. A young monocot has a single seed leaf.
15. True
16. False. They are derived from the parts of ovaries.
17. False. They are generally produced by planting their tubers.
18. True
19. True
20. False. It is the scion that produces the fruit.

DISCUSSION QUESTIONS (page 453)

1. In growth from parts there is only one parent which produces the bulb or tuber from which the new individual is developed. This is an asexual process. A seed, however, can only be produced through the union of a male sex cell and a female sex cell, and this is a sexual process.
2. The seed is more likely to produce a new plant, because it contains stored food that will support the early growth process, and may therefore sprout under less than ideal conditions. A spore, on the other hand, must be in a wholly favorable situation if it is to germinate successfully.
3. Pollen grains are produced by the anthers of flowers. They are considered to be male structures because pollen grains contain cells which produce the sperm nuclei.
4. The egg cells of a flower are produced in its ovaries. Some flowers have only stamens, and therefore do not produce egg cells.
5. The species that is wind-pollinated is more likely to have incomplete flowers. It does not need to have the bright petals that seem to attract insects.
6. Bees are generally seeking nectar and pollen when they visit flowers. The plants benefit because the bees pollinate them.
7. No, such a plant cannot be self-pollinated. Since it has no stamens, it cannot produce pollen, and pollen must come to it from another plant.
8. The pollen tube grows progressively down through the style until it reaches the portion of an ovary in which egg cells are located. Then one of the sperm nuclei unites with a mature egg cell to produce a fertilized egg cell.
9. After an egg cell has been fertilized it begins to divide, and produces numbers of cells that form a plant embryo. These cells are organized in the form of one or two seed leaves, and an embryonic structure that will give rise to the root system, stem, and leaves of the new plant. Some cells also go into

the seed case that surround the embryo.

10. Fruits are normally developed around seeds or attached to seeds. The fruit structures develop from tissues of the plant ovary.
11. Some fruits stick to the fur of animals, and others are eaten by animals; in either case the seeds are likely to be scattered widely. Other fruits are winged, and are carried long distances by the wind, or are fruits that burst open when they ripen and literally "throw" their seeds.
12. Higher plants cannot move about and select suitable places for growth. If their seeds merely fall to the ground nearby, the resulting plants are soon badly crowded and many of them are doomed. When seeds are scattered, there is less competition among the resulting offspring, and some of the seeds are likely to sprout in favorable spots which may be at some distance from the place where the seeds originated.
13. Plant seeds are present in a good deal of farm produce that is carried from one place to another. In most cases, man is not seeking to scatter the seeds, but does so accidentally.
14. The most obvious difference between a young monocot and a young dicot is that the former has a single seed leaf while the latter has two seed leaves.
15. Conditions that favor sprouting and growth are a fertile soil, favorable temperature, and the presence of suitable water and oxygen supplies.
16. We raise potatoes from cuttings because this practice enables us to get a crop in a single growing season. The edible portions of carrots and radishes, however, can be raised from seeds within a single growing season.
17. There are two general advantages in raising some plants from cuttings. One is that you maintain the same heredity in the offspring, which is desirable if the parent plants were of a superior type. The other is that raising plants from cuttings will often speed up production so that you do not have to wait as long to get a crop.
18. As described in the text, plants that can be raised from underground parts include grasses, potatoes, tulips, lilies, irises, daffodils, gladioli, and begonias. Plants grown from stems or shoots include strawberries, willow trees and geraniums.
19. This can be done by grafting several kinds of apple scions on a single apple rootstock.

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CHAPTER 20 Animal Reproduction

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Animals employ asexual or sexual means of reproduction, and both types in some of the less complex species.	
2. Reproduction by Invertebrates		Things To Do, #1 (p. 473) Crayfish Eggs (p. 461) Things To Do, #2, and 3 (p. 473)
A. Ameba divides	Ameba grows to full size, and then divides by a simple type of mitosis. A related genus called **Chaos** divides to form three daughter cells.	
B. Spore formation	Various simple animals form sporelike cells.	
C. Volvox	**Volvox** lives as a colony of cells. Most of these cells are somatic, but a few of them become special sex cells.	
D. Sponges and corals	Sponges and corals have some solitary species and some species that are colonial. Both types reproduce by budding (asexual), and by means of male and female sex cells (sexual).	
E. Flatworms and roundworms	The members of these two phyla produce sex products. In the flatworms both sexes usually are present in one individual, but in the roundworms the sexes are generally separate. These worms have a rapid potential rate of reproduction.	Regeneration in a Flatworm (p. 529)
F. Earthworm reproduction	Earthworms reproduce sexually, but are hermaphroditic, and within certain limits, they have good powers of regeneration.	
G. Oysters and their eggs	Female oysters discharge eggs into the water, and male oysters discharge sperms at the same time. Fertilization is by chance	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	encounter. Oyster embryos lead free-swimming lives for a period, and then become attached to solid objects in the water.	
H. Insect reproduction	Female insects generally lay eggs, but the insects known as aphids bear some generations of their young.	
3. Reproduction in Vertebrates	In the vertebrates reproduction is sexual, and there usually are separate male and female individuals.	Things To Do, #4, 5 (p. 473)
A. Reproduction of fish	Fish are generally egg layers, but a few species bear their young. Many fish eggs fail to be fertilized, and many young fish are destroyed.	
B. Reproduction of amphibians	Most female amphibians lay eggs, but a few types bear their young. The early part of the amphibian life cycle is usually spent in the water. Thus, female frogs lay masses of eggs in shallow water, which are fertilized by a male frog as they are deposited. Tadpoles develop from these eggs, and use gills to get oxygen from the water. Later, the tadpoles develop lungs, and move out on the land.	Development of an Amphibian Embryo (p. 530)
C. Reproduction of reptiles	The sexes are separate among reptiles, and the majority of females are egg layers. In some species, however, the eggs hatch within the females' bodies, and the young are born.	
D. Reproduction of birds	In birds, sexes are separate, and the females are all egg-layers. Many birds provide parental care for their young.	Structure of an Egg (p. 467) Things To Do, #6 (p. 474) Development of a Chick Embryo (p. 531)
E. Reproduction of mammals	Sexes are separate, and a few primitive mammals are egg-layers. The kangaroos	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	and their relatives produce young in a very immature state. In most female mammals a placenta is developed for the protection and nourishment of the young. This placenta is formed in the cavity of the uterus.	
4. Animal Development	All higher animals develop from single cells—fertilized egg cells, which contain the DNA that directs the formation of the particular animal types. Cell division takes place, and many of the new cells so-produced become specialized for various functions.	
A. Early stages in development	In various species, the cells first become organized to form a hollow ball or blastula. Then the basic cell layers are formed: the ectoderm, the mesoderm, and the endoderm. From these three basic cell layers all of the tissues, organs, and systems of the adult are produced. The process of development, however, varies among different higher animals.	

RELATED FILMS

	Min.		
Beginnings of Vertebrate Life	11	Color	EBF
Development of the Chick	11	B&W Color	UW
Flatworms	16	Color	EBF
Life Cycle of the Frog	11	B&W Color	UW
Paramecium	11	B&W Color	UW
Reproduction Among Mammals	11	B&W	EBF
Sea Island	27	Color	FI
The Chick Embryo: From Primitive Streak to Hatching	13	Color	EBF
The Living Bird	14	Color	IFB

OVERVIEW AND RATIONALE

Some of the simplest animals reproduce by asexual means such as cell division and budding. There are other more complex types that retain the ability to reproduce asexually, but also develop male and female sex cells. Sponges and corals, for example, can reproduce by budding, but they also have a sexual type of reproduction in their life cycles.

Some of the flatworms can also reproduce asexually, and have good powers of regeneration. In these flatworms an individual generally develops both male and female sex cells, and eggs are produced. In the roundworms, however, the sexes are generally separate, and while egg laying is the general rule, some females bear their embryonic young. The number of eggs produced by parasitic worms is generally very large.

In the mollusks and higher forms of life, the sexes are generally separate, and reproduction is normally confined to sexual processes. The reproduction of oysters is typical of many invertebrates that live in the sea or in fresh water. Female oysters produce vast numbers of eggs that are discharged into the water, where fertilization depends upon chance encounter with sperms of male oysters. If fertilization takes place, small ciliated embryos develop. These embryos swim about near the surface for some time, and then drop to the bottom where they spend their adult lives.

Insects are generally egg-layers, and their young exhibit two general patterns of development, which feature either complete or incomplete metamorphosis. Females of some insect types, however, bear some generations of their young.

Among vertebrates, sexual reproduction is the rule, and the ability to regenerate is generally limited. Fish, amphibians, and reptiles usually are egg-layers, but in each group there are some species that bear their young. Various amphibians have life cycles that begin in the water and terminate on land. Many reptiles are adapted to the land environment throughout their life cycles.

Birds are universally egg-layers, and so are three species of primitive mammals. Most of the female mammals develop placentas, which nourish the young in the period prior to birth.

The process of development varies considerably among animals, but in its early stages three basic cell layers are formed, and they give rise to the same or similar tissues in all animal types. The specific course taken by development is believed to be governed by the type of *DNA* contained in the fertilized egg cell, since all of the complex animals begin their life cycles as single cells.

GETTING STARTED

Students will already have some background that relates to the ways in which the simpler animals reproduce. One way to continue the learning process is to review earlier studies having to do with spore formation, simple cell division, budding in hydra, and the appearance of sex cells in some of the lower animals.

With this start, it is easy to progress to the subject of reproduction among invertebrates, which, with a few exceptions, is a story of egg production. Be sure to note that these eggs are often produced in very large numbers, and that the potential rate of population increase is very high. If "berried" female crayfish can be obtained, the observation described on page 461 will lend considerable interest to this study.

Note that reproduction among fish, amphibians, and reptiles usually follows the familiar egg-laying pattern. The life cycle of a frog is especially significant, because the ancestors of the amphibians managed to make the transition from aquatic life to terrestrial life, although it probably required many generations to effect this achievement.

You can introduce reproduction in birds with the observation of egg structure described on page 467. While students have seen eggs many times, you will probably find that many of them have not grasped the concept of egg structure including how an egg can produce a bird. The study of young chick embryos described on page 531 will reinforce and clarify this learning experience.

In the case of mammalian reproduction, the significant concept is the manner in which a placenta is formed, and the way in which it functions. It is the structure that enables food material to reach the developing animal, and at the same time provides an avenue for the removal of waste products that come from the developing animal.

CLASS NOTES

Reproduction by Invertebrates (page 456) Among sponges and corals are found some types that live as solitary or single individuals. When such individuals produce buds, the buds soon separate from the parent and lead separate lives. However, many species are colonial, and in this case buds remain attached to the parent colony. This attachment depends upon the presence of skeletal material, which is present in both sponges and corals. Various sponges have skeletons of lime, silica, or spongin; coral skeletons are generally of lime.

Both sponges and corals develop sex cells, and free-swimming embryos are represented in their life cycles. This fact is important, because adult sponges and corals are fixed in position, and therefore at the mercy of tides and sediments. The existence of motile embryos makes the establishment of new colonies in favorable locations a possibility.

It is also noteworthy that various members of these groups have good powers of regeneration. For example, "cuttings" taken from commercial sponges are used to "plant sponge farms" in shallow, warm sea water. Hydra also has remarkable ability to regenerate lost parts.

Planaria is a free-living flatworm, which sometimes reproduces by fission through its short axis, and sometimes by sexual means.

The sheep liver fluke is another type of flatworm. It is a parasite that lives as an adult in the bile ducts of sheep and other animals. Each fluke develops male and female sex organs, and thousands of eggs pass out through the bile passages and intestines of the host. If the eggs get into water they produce larvae that become parasitic in the bodies of snails. In the snails, the larvae produce one or more generations of new larvae, after which young flukes called cercariae leave the snail hosts and form cysts on grass blades near the water's edge. Sheep eat this grass, whereupon the flukes are back in the body of their adult host.

Various species of tapeworms develop many body segments, and male and female sex organs soon appear in each of them. By the time a segment at the end of a tapeworm's body is mature, it is little more than a capsule enclosing a mass of eggs.

In roundworms the sexes are generally separate, but methods of reproduction and development vary considerably. In the eel worm, for instance, the eggs are fertilized in the female worm's uterus, after which they are discharged from her body. Since the female worm is in the human intestine at the time (in most cases), the eggs pass out of the body with the wastes, and may lie about on the soil surface until another human host happens to swallow some of them accidentally. Trichina worms, which are also roundworms, have a different type of development which includes encystment in the muscles of their hosts.

During the reproductive season the surface of the shallow sea may be literally teeming with the larvae of oysters, as well as the larvae of many other marine invertebrates. A large proportion of these larvae fail to survive.

At the time when they attain the bottom-seeking stage, oyster larvae are called spat. A spat is about 1/75th. inch in length, and is ready to start forming a shell. Adult oysters are sessile, or fixed in position, but some of their relatives remain unattached throughout life.

Various freshwater clams present an intersting case, because for a period of time their larvae are parasitic upon fish.

During the summer period the aphid world is populated only by females. Successive generations of these females bear their young, and they do so without having been fertilized. Then the final autumn generation appears, in which the two sexes are about equally represented. The underlying causes that produce this sequence of events are not known.

Reproduction Among Vertebrates (page 462) A male bird has two testes, but an adult female usually has only one ovary—the left. In a few adult birds the right ovary, or a portion thereof, persists in the adult.

Animal Development (page 468) Cleavage is the process in which a fertilized egg cell divides repeatedly to form a blastula. Two of the basic cell layers become differentiated in the next step, and the young animal is called a gastrula. Now a third basic cell layer forms between the original pair.

The manner in which these developmental processes takes place varies in different animal types. Thus, in the case of a starfish egg, clevage is equal, whereas in the frog egg, clevage is unequal. In higher types of animal life there are two other types of cleavage: a) meroblastic, in which the entire egg never does divide, and b) superficial, in which only the nucleus of the egg divides. Moreover, the manner in which a blastula becomes transformed into a gastrula differs among animal species.

It is also noteworthy that there are various types of mammalian placentas. In general, however, the blood of the parent does not come in actual contact with the blood of the embryo. Apparently many germs cannot bridge the gap, but the syphilis organism is able to do so, and occasionally the tuberculosis organism as well.

LABORATORY SUGGESTIONS

Crayfish Eggs (page 461)

Materials: battery jar, female crayfish with eggs, blank slide or small crystal watch glass, microscope.

There are two genera of North American crayfishes, and in both types the females carry their eggs attached to the swimmerets of their abdomens. After the eggs hatch, the young crayfish remain attached to their parents' abdomens for some time.

In the spring of the year you can often find female crayfish under small rocks in shallow water along the borders of a stream or pond. A pond net will be useful in capturing specimens. To transport specimens, put two or three in a collecting jar that contains only a half-inch of water. Pull up some grass or clover, and cover the specimens. Do not cover the jar with a lid or cap.

ANALYSIS QUESTIONS (page 461)

1. The eggs are attached to the short appendages (swimmerets) on the underside of the female's abdomen.
2. A hard outer skeleton limits growth. If growth is to proceed, the outer skeleton must be shed or molted periodically.

Structure of an Egg (page 467)

Materials: egg, Syracuse watch glass, scalpel, forceps, scissors.

You will find that a Syracuse watch glass is the right size to hold a hen's egg in a fixed position. You have to remove the bits of shell very carefully so as to avoid damaging the yolk surface.

The twisted, dense portions of egg white are the so-called chalazae. Note that one of them is coiled clockwise, while the other is coiled counterclockwise. The chalazae act to keep the same part of the yolk upright whenever the egg is at rest.

If an egg has been fertilized, development has already begun at the time the egg is laid. A small patch of cells is already present on the upper surface of the yolk.

ANALYSIS QUESTIONS (page 467)

1. The egg yolk contains the original nucleus, and also a good deal of stored

food which will be used by the embryo in growth and development. Later on, the developing chick will draw upon the egg white for nourishment.
2. Since the embryo develops on the upper side of the yolk, the weight of the yolk does not press down upon it.

WORD MEANINGS (page 470)

1. blastula—a hollow ball of cells formed during development.
2. placenta—structure for the nourishment of developing mammals.
3. aphid—a small insect that feeds on plant sap.
4. uterus—structure of female mammals in which the young develop.
5. umbilical cord—connects the placenta with the developing mammal.
6. gastrula—young animal that has two of the basic cell layers.
7. mesoderm—the third basic cell layer of an embryo.

SELF TEST (page 471)

1. True
2. False. An ameba is constantly changing shape when it is active.
3. True
4. False. Somatic cells are body cells; it is the sex cells that produce sperms and egg cells.
5. True
6. False. They are permanently attached to solid objects.
7. True
8. False. An individual flatworm generally has both male and female sex organs.
9. False. Only a small percentage of the eggs develop into adults.
10. True
11. False. They can regenerate some, but not all of their parts.
12. False. Fertilization takes place by chance encounter of sperms and egg cells in the water.
13. False. A female crayfish carries the eggs attached to her abdominal appendages.
14. False. No vertebrates reproduce by budding.
15. True
16. True
17. False. The eggs are fertilized as soon as they are laid.
18. True
19. True
20. False. Most bird species require a period of parental care which may extend through several days.
21. False. The female duckbill is unusual because she lays eggs.
22. True
23. True
24. True
25. False. One combination of *DNA* molecules produces a cat, and another combination of *DNA* molecules produces a dog.
26. True
27. True
28. False. They develop from the ectoderm layer.
29. True
30. False. The egg nucleus divides and a group of cells forms on the surface of the egg yolk.

DISCUSSION QUESTIONS (page 472)

1. Some reproduce by cell division, some produce sporelike cells, and some develop sex cells. So you find examples of both asexual and sexual reproduction.
2. An ameba divides by a simple type of mitosis.
3. Encysted protozoa of some types divide within their cyst walls to form a number of spores.
4. Sex cells have only one main function, which is reproduction. Somatic cells include all of the other cells in a body.
5. Colonial sponges and corals are made up of many individuals that are all joined together by a common skeleton. A colony that grows as buds are produced, and these buds develop into new members of the colonial group.
6. Some flatworms reproduce by trans-

verse fission, but most of them produce large numbers of eggs. Male and female sex organs are generally lodged in the same individual. In roundworms the sexes are usually separate, and reproduction is by means of eggs, which are also produced in large numbers. In a few roundworms the eggs hatch while still in the body of the female, and the embryos are born.

7. Two earthworms come together and exchange sperms. Then the sperms of worm *A* fertilize the egg cells of worm *B*, and vice versa.
8. Certain species of planaria have somewhat greater powers of regeneration than earthworms do. You can bisect these planarians transversely, and both head and tail ends will regenerate under favorable conditions. If you bisect earthworms transversely, only the head ends will survive and regenerate new segments.
9. Fertilization is by chance encounter of sperms and egg cells in the water, and many egg cells are not fertilized. If the free-swimming larvae do form, large numbers of them are eaten by various marine animals. If the larvae survive to become young oysters they are subject to attack by starfish, drilling snails, and other animals, and they are sometimes killed because they were buried by sediments.
10. Reproduction of an aphid is unusual because during the summer season only generations of females are produced, and these females bear their young without having been fertilized. In a fall generation both males and females are produced, whereupon the males fertilize the females, and the latter produce the eggs that hatch the following spring.
11. A female crayfish carries both her eggs and her young attached to her swimmerets. Thus, they are protected against any animal that the female crayfish can combat successfully.
12. The female yellow perch lays about 100,000 eggs on the bottom in shallow water. The male perch discharges sperms into the nearby water. A number of the eggs probably do not get fertilized. In some other fish species, the male fertilizes the female, and in certain cases the eggs hatch while they are still within the body of the female.
13. Both tadpoles and adult frogs obtain some oxygen through their skin layers. In addition, a tadpole develops external gills, then internal gills, and finally lungs. When lungs have formed, the tadpole is ready to leave the water and become an adult. When in hibernation, the adult frog gets oxygen through its skin.
14. The yolk contains the egg cell nucleus, and it develops while it is still attached to the hen's ovary. During this period or shortly thereafter it is fertilized. The yolk enters the oviduct, and cells of the oviduct secrete the white of the egg around it. Then other cells secrete the shell membranes, and still other cells secrete the shell. Now the egg is ready to be layed.
15. Duckbills and spiny ant eaters are egg-layers, but possess milk glands like other mammals. Kangaroos and opossums produce their young in a very immature condition, and carry them around in their marsupial pouches for a period of time.
16. The uterus is the portion of the female reproductive system in which a young mammal develops. Part of the placenta is developed from cells that line the uterus.
17. The placenta is a special structure for the protection and nourishment of the developing mammal. It is derived in part from cells of the uterine lining, and in part from cells produced by the young unborn mammal.
18. Apparently the type of *DNA* molecules contained in a fertilized egg cell determines what sort of embryo or adult will be developed from this egg cell.
19. A blastula, as formed in starfish and

some other animals, is a hollow sphere of cells that develops during cleavage. Development continues, and two basic cell layers are formed to produce a gastrula. So the gastrula develops from the blastula.

20. The three basic cell layers and their derivatives are as follows:
    Ectoderm—outer skin layer, hair, nails, feathers, scales, plates, nervous system
    Mesoderm—sex cells, muscles, connective tissues, internal skeleton
    Endoderm—lining cells of certain internal organs, such as the stomach and small intestine
21. In early development a starfish egg undergoes equal cleavage. The entire bird egg never does divide; instead, a group of cells is formed on the surface of the yolk, and from these cells the embryo is developed.

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CHAPTER 21 Inheritance In Plants And Animals

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Human interest in heredity is not new, because men have raised plants and animals for centuries. Formerly, these plants and animals were improved through mass selection. The modern study of heredity was begun by Gregor Mendel in the latter part of the nineteenth century.	
2. Causes of Variation	Variations among members of a species are in part due to differences in heredity. Otherwise, they are due to environmental forces that are constantly brought to bear upon all individuals.	
3. Determination of Sex in Man	Sex in man is determined by heredity. A fertilized egg cell that has two X chromosomes produces a female, and a fertilized egg cell that has one X chromosome and one Y chromosome produces a male. A great variety of contrasting characters or traits can be inherited.	
4. Hereditary and Acquired Characters	Hereditary characters can be passed on from generation to generation, but some of them can be greatly modified by environmental forces. Acquired characters are not inherited. They represent changes that affect only the somatic cells.	Your Own Hand (p. 480) Your Ear Lobes (p. 481) Variation in Leaves (p. 481) Things To Do, #1, 2, 3 (p. 493) A Cellophane Model (genes) (p. 532)
5. Mutations	Mutations are new, hereditary characters. Presumably they are due to changes in the DNA molecules of sex	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	cells. Many mutations are of a minor nature. Most are damaging, and among them are mutations that cause early death of developing individuals. Some mutations are beneficial.	
A. Examples of mutations	The ancon sheep (1791) and polled hereford cattle (1889) were the result of single mutations. Many other examples have been observed in nature.	A Problem of Albinism (p. 487)
B. Harmful and desirable mutations	In nature, the majority of mutations are harmful, but at the same time some of them are of a minor nature, and lethal mutations leave no permanent imprint upon the species. Desirable mutations do appear now and then.	
6. The Nature of Hybrids	A pea plant may have one gene for tallness and one gene for shortness, in which case it is a hybrid for this trait. But it is not necessarily a hybrid for many other traits.	
7. Mendel's Experiments	Mendel crossed **TT** peas with **tt** peas to produce a generation of hybrids that were all tall. Mendel concluded that tallness in peas is dominant over shortness. Mendel then crossed the **Tt** peas of this hybrid generation, and obtained offspring in the ratio of **TT** + **2Tt** + **tt** (three tall and one short).	Using Genes to Predict Genetic Proportions in Offspring (p. 532) Things To Do, #4 (p. 494)
A. Incomplete dominance	In some gene pairs, neither gene is dominant over the other.	
B. Complex cases of inheritance	Some human traits are affected by more than one pair of genes.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
8. Desirable Traits	We desire a variety of traits in the plants and animals that we raise. We use our knowledge of Mendel's laws to produce improved types.	Investigating Albino Corn (p. 533) Study of a Human Pedigree (p. 534) Things To Do, #5, 6 (p. 494)
A. Sources of useful characters	Some are discovered in related wild species, and some result from mutations of cultivated and domesticated types.	
B. Tailor-made plants and animals	Mendelian methods are used to establish desired traits in various breeds of plants and animals.	
C. Test crosses	Test crosses are made to distinguish individuals that have two genes for a desired dominant character from individuals who have only one dominant gene for this character.	
D. Hybrid varieties	We raise many hybrid plants today. The result has been particularly satisfactory in the case of hybrid corn. The production of these hybrids, however, necessitates the use of genetically prepared seeds. Standard pure lines, on the other hand, can be reproduced from their own seeds.	

RELATED FILMS

	Min.		
Genetics	53	B&W	USDA
Genetics: Mendel's Law	13	B&W Color	COR
Heredity	11	B&W	EBF
Heredity and Environment	11	Color	COR
Heredity and Environment	30	B&W	IU
Heredity and the Chromosomes	30	B&W	IU
Heredity in Animals	11	B&W	UW
Human Heredity	18	Color	IFB
The Sex Chromosomes	30	B&W	IU

OVERVIEW AND RATIONALE

The mass selection methods men have used since the beginnings of agriculture produced great improvements in plants and animals, but often the improvements came only after years of effort. The experiments performed by Gregor Mendel opened the way for the modern study of heredity and its many applications to human affairs.

Variation is an established fact in nature. The members of a given species all differ from one another. In part, the individual differences are inherited, but some of them are due to contact with the environment. Hereditary characters are passed on through a long series of generations, but acquired characters leave no imprint upon the sex cells, and are therefore not inheritable.

Mutations are hereditary changes in the genes of sex cells. It is believed that in some way certain *DNA* molecules in the genes become modified. Many mutations are minor in their nature; some are lethal or otherwise harmful, and others are beneficial. But apparently the majority of mutations, including both major and minor types, are in the harmful category.

Mendel experimented with tallness and shortness in peas. He discovered that hybrid (Tt) peas appeared tall, and concluded that tallness was dominant over shortness in this species. When he crossed hybrid peas ($Tt + Tt$) he obtained offspring in the ratio of $TT + 2Tt + tt$ with two-thirds of the plants appearing tall. It was later discovered that there are various cases of incomplete dominance in nature, and that the inheritance of some traits is influenced by several pairs of genes. But all cases of inheritance appear to follow the Mendelian pattern.

We desire a wide variety of characters in the plants and animals that we raise. They include such things as immunity to certain diseases, products in quantity and quality, and ability to grow under various conditions. Some of the desired traits may be found in related wild varieties, and others result from mutations. Mendelian methods are used to incorporate the desired traits in plant and animal varieties that will breed true. Test crosses are made to distinguish pure dominants from hybrids in the event that the desired character is a dominant.

We now produce many plants from genetically prepared seed. Often this practice provides more satisfying yields, but it is subject to the handicap that only specially prepared seeds can be used. Standard line plants can be reproduced from their own seeds, which makes seed production much simpler.

GETTING STARTED

A good introduction to the basic concept of variation is to carry out some or all of the observations described on pages 480-482. Students are, of course, aware that individual variations exist, but they may be surprised by the nature and extent of some of them. Prior to this time the students probably have noted occasional variations only, and in a rather off-hand manner. You can follow this experience with a discussion of what causes variations, and the difference between acquired characters and mutations.

In studying Mendel's law of monohybrids it is sometimes difficult for a student to realize that a Tt plant will be just as tall as a TT plant; apparently at first thought this does not seem reasonable to some people. Once they have this basic idea in mind, however, the rest may come easily. It is a good idea to have the students practice on a number of simple crosses, using the system described on page 484 to make their predictions. They will also profit from doing the *A Problem of Albinism* described on page 487.

Now a discussion can deal with ways in which Mendelian selection is used to produce more desirable varieties of plants and animals. Note that Mendelian methods get results much faster than mass selection, in the case of desired traits that are dominant. Have students explain the test cross described on page 490, and indicate how it might prove useful in producing a pure line of some special variety.

CLASS NOTES

The Causes of Variation (page 475) At birth or hatching an individual possesses a certain combination of hereditary characters that differs from the combinations of these characters found in all other members of the same species, with the exception of identical twins. Even in this case there may be some differences because a certain amount of development has taken place before birth or hatching occurs. Other acquired characters are soon developed through contact with the environment. So adult organisms are likely to exhibit even greater diversity than you find in comparable groups of young organisms.

What causes mutations in a state of nature is still an open question for the most part. In the laboratory the rate of mutation production has been increased by employing X rays, certain chemicals, and temperature effects. It is also known that in reproductive processes the chromosomes sometimes are accidentally doubled, or tripled, and that some chromosomes may be lost or damaged. It is postulated that mutations in nature may be due to similar things and forces, including temperature changes, chemical action, cosmic radiation, and radiation from isotopes in the earth's crust.

Mendel's Laws (page 482) Gregor Mendel was an Austrian monk who lived in the town of Brünn, which is now Brno, Czechoslovakia. He experimented with plants in his spare time, keeping individual records of crosses, seeds, and their products. The word "gene" was not used in Mendel's day, but Mendel recognized hypothetical components in sex cells, which he called "factors," and he concluded that for a given trait a new individual must receive one factor from its male parent and a corresponding factor from its female parent.

The "natural" rate of mutation in certain organisms has been studied, and found to be about one mutation per million cells. Note that mutations can occur in somatic cells as well as in sex cells, but only the latter will affect future generations in the more complex organisms.

Another significant fact is that mutations are purely random and quite unpredictable. When they occur, they may be lethal, they may be harmful but not lethal, they may be of no obvious consequence, or they may be beneficial. The plant breeder, looking for a certain type of mutation, has to be patient and hope for the best.

Since the majority of mutations are disadvantageous, dominant mutations are not as likely to be continued in the race as are recessive mutations. This is because a damaging dominant mutation is likely to cause the elimination of the individual possessing it. On the other hand, two-thirds of the individuals possessing damaging recessive genes are hybrids, and do not develop the handicaps that would be imposed if they had a pair of these genes.

Better Plants and Animals (page 488) Some plant species have been under cultivation for a very long time, and many different varieties have been produced to meet the demands for plants that will grow under rather limiting conditions, and the demand for plants that produce special types or qualities of products. Today we have many varieties of wheat, rice, cotton, and corn that have been developed to meet such demands. Similarly, there are many different breeds of cattle, some of them being beef cattle, some milk cattle, and some cattle that produce both beef and milk. In the case of animals that we raise for fur, the demand is often for something that is new or rare, such as mutant types of minks or foxes.

LABORATORY SUGGESTIONS

Your Own Hand (page 480)

Materials: sheet of paper, pencil, ruler.

Everyone realizes to some extent that human hands vary, but people seldom pause to study the nature and extent of this variation. In making the measurements, assume that the wrist begins at the proximal ends of the wrist bones or metacarpals. The knuckle line can be drawn through the knuckle of the middle finger.

ANALYSIS QUESTIONS (page 481)

1. Answers will vary, but it would be most surprising if all the students had first fingers that were longer than their third fingers.
2. The probable answer is a negative. Some hands are broader than others, and some hands are longer than others.

Your Ear Lobes (page 481)

Materials: none.

If you obtain the results of this observation from a fairly large number of students you can probably decide whether the free lobe is dominant or recessive. However, it should be understood that a trait is not necessarily dominant just because it is more common than the contrasting trait.

ANALYSIS QUESTIONS (page 481)

1. Both answers will vary, but examples of the two types should appear in any student group of moderate size.
2. There may be a few cases in which it is difficult to decide whether the lobes are free or attached. In rare instances you may find a right lobe that differs from the left.

Variation in Leaves (page 481)

Materials: 40 leaves selected according to the directions, a ruler.

To get a fair comparison, select all of the leaves from about the same height on the tree. Be sure that the "shady side" of the tree is really shaded most of the time.

ANALYSIS QUESTIONS (page 482)

1. Answers will vary, but the expectation is that the shady side leaves will be longer than the sunny side leaves.
2. Answers will vary.
3. Most of the differences were probably due to the effects of the environment.

A Problem of Albinism (page 487)

Materials: 80 colored beans, 20 white beans, a bag to hold the beans.

In carrying out this experiment you are simulating random crosses as they might occur in nature. Among wild animals, albinism is likely to be a severe handicap, but it is also likely to persist in the species, because the albino gene is a recessive, and hybrids do not develop the handicap.

ANALYSIS QUESTIONS (page 488)

1. Answers will vary, but the probability is that from 50 pairs, about 32 will represent *PP*, 16 will represent *Pp*. and 2 will represent *pp*. If students group all of their data, they will be more likely to achieve the probable ratio of 64 percent *PP*, 32 percent *Pp*, and 4 percent *pp*. The important thing is to note how few *pp* combinations can be expected in such a population.
2. The percentages of *P* and *p* will remain the same. In the group composed of 32 *PP*, 16 *Pp*, and 2 *pp*, the percentage of *P* is still 80, and the percentage of *p* is still 20.

WORD MEANINGS (page 491)

1. For many years gardeners in the Brown family save and plant seeds of the best radish plants they produce. In time, they are raising an improved type of radish. The process they have used is called (*c*) mass selection.
2. A grasshopper begins life in a normal fashion, but one day it loses its left front leg. This change in the grasshop-

per's structure is an (a) acquired character.

3. A certain plant bears white flowers. Its sex cells are acted upon by X rays so that their *DNA* molecules are changed. The offspring of this plant bear red flowers. This change in flower color is a (*d*) mutation.
4. *BB* (brown) is crossed with *ww* (white). All of the *Bw* offspring are brown. This is an indication that the *B* gene is a (*b*) dominant.
5. *RR* (red) is crossed with *ww* (white). All of the *Rw* offspring are pink. This is an indication that the *R* gene is an (*c*) incomplete dominant.
6. Two black crow parents produce a young bird that has white feathers and red eyes. The evidence suggests that the young bird is an (*b*) albino.
7. Tallness (T) is dominant and shortness (*t*) is recessive. You cross a number of *Tt's* and produce 100 offspring. Seventy-five of these offspring are tall, and 25 are short. How many of them are probably hybrids (*Tt*)? (*b*) 50

SELF TEST (page 492)

1. False. Mendelian methods have only become available in the present century; mass selection has been used for thousands of years.
2. True
3. True
4. False. The male has one *X* chromosome and one *Y* chromosome.
5. False. Environment has very great effects upon some characters.
6. True
7. False. No acquired characters are known to be inherited.
8. True
9. True
10. False. The majority of mutations are harmful.
11. True
12. True
13. False. There are numerous examples of incomplete dominance.
14. True
15. False. Some characters are affected by several pairs of genes.
16. True
17. True
18. True
19. False. Seeds from hybrid plants will not produce another crop of the same nature.
20. False. Many of the plants that we raise are special hybrid varieties.

DISCUSSION QUESTIONS (page 492)

1. The significance of discoveries is sometimes overlooked until a much later date because at the time of the discovery not enough is known about the subject.
2. One reason why we fail to observe many examples of variation around us is that we are not looking for them. Also, a certain amount of training and experience is helpful in identifying variations.
3. In the genes of sex cells *DNA* molecules are combined with protein molecules to form nucleoprotein molecules. It is believed that genes are composed of these nucleoprotein molecules.
4. In man, sex is determined by heredity. If the fertilized egg cell contains two *X* chromosomes, the result is a female. If it contains one *X* chromosome and one *Y* chromosome, the result is a male.
5. The two general forces that act to produce differences among the individuals of a species are a) heredity, and b) the effects of environment.
6. One common manner in which organisms develop acquired characters is through injury, including loss of parts. But there are many other kinds of acquired characters. For example, you develop strong muscles by exercise or by doing certain kinds of work.
7. Mutations are new hereditary characters, that come into existence because *DNA* molecules in genes have been modified. Some mutations are also due

to a change in chromosome number, or to physical changes in chromosomes.

8. A mutation of this type causes the death of the individual during development. Thus, this individual does not reproduce, and does not pass on the defective gene to any descendants. The species is not affected in any way by the mutation, except that one of its members has been eliminated.
9. A mutation that produced a pure white type of mink might be very desirable from our standpoint, assuming that natural white mink became a much sought after fur. In nature, however, a mink of this type might be badly handicapped. The mink is a hunter, and white color might warn its prey of the mink's presence. Moreover, if the white color was due to an albino condition, the mink's vision probably would be impaired.
10. In heredity, one or more pairs of genes are responsible for the inheritance of a given character. It is quite possible to be *TT* for one character, *BB* for another, and *Aa* for still another. Here, only the *Aa* character would be hybrid.
11. When *RR* is crossed with *ww*, 100 percent of the offspring will be red. Also, 100 percent of the offspring will be hybrids for color.
12. This albino would first be more conspicuous than an animal of normal color. Its natural enemies would see it easily. If it was a hunter, its intended victims would see it coming. In addition, an albino is likely to have poor vision.
13. When we seek to improve plants that we raise there are many different qualities that we may be seeking. They include such things as immunity to disease, a larger yield, a yield of a certain quality, the ability to grow and mature under a variety of conditions that involve temperature, moisture, soil conditions, or wind effects, and many others. In the case of ornamental plants, a red flower may be preferred over a white flower, or vice versa.
14. The superiority of Mendelian selection relates to the fact that you can predict what the offspring will be. Suppose you want to develop a pure red variety in the case that red (*R*) is dominant and white (*w*) is recessive. If you use mass selection, all you can do is pick out certain red individuals as breeding stock. However, you do not know whether they are *RR* or *Rw*, and since the *Rw's* are twice as numerous as the *RR's*, you are almost sure to include some of them in the breeding stock. In Mendelian selection, you would proceed to make test crosses, as described on page 490, and you would eliminate the *Rw's* from the breeding stock. Thus, you would soon know that your breeding stock was exclusively *RR*, and that the offspring would all be red, provided no color mutations appeared.
15. Using the same example we have used in item 14, the test cross is used to distinguish between the individuals that are *RR* and the individuals that are *Rw*. You cross all of them with *ww* or white. If the individual tested is *Rw*, half of the resulting offspring will be white, but if it is *RR*, none of the resulting offspring will be white. Now you have identified the *RR* individuals, and you use them to produce your new variety.
16. Environmental conditions vary in different parts of North America. If you lived in the northern region you would need a corn that matured rapidly, because the growing season is relatively short. If you lived where winds often blow with considerable force, you would need a corn that develops a strong root system. You might want a white corn, a yellow corn, or a red corn for various reasons, or a sweet corn rather than a field corn. As a result, the seed producers develop a variety of hybrid corn plants.

17. No, we do not always prefer the "biggest" product. Sometimes the smaller food types have better flavor than the larger ones. Sometimes a small furbearer is preferred over a larger one, perhaps merely because it is rarer and more expensive. Or, consider the case of cotton. We usually raise cotton to get its seed hairs, which are woven into thread and fabric. For such a purpose we want a cotton variety that produces plenty of long, strong seed hairs. But sometimes we merely raise cotton so that we can extract oil from its seeds. For this purpose a cotton variety with only a few short seed hairs is preferred.

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CHAPTER 22 Natural Selection

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	Fossils are evidences of past life that have been preserved in rocks. The hard parts of plants and animals become covered with sediments, and later on the sediments are solidified into rocks. Fossil formation still takes place in our modern world.	
2. The Fossil Record		
A. The age of invertebrates	This age dates back millions of years into the past. Dominant forms of life were marine invertebrates such as sponges, corals, and mollusks.	
B. The age of fishes	Fishes that lived in the shallow seas were the first vertebrates to become dominant.	
C. The age of amphibians	Vast swamps existed, and amphibians developed from fish ancestors. Land plants and insects also came into existence.	
D. The age of reptiles	Reptiles arose from amphibian ancestors, and were dominant forms of life for about 140 million years. Meanwhile, the first birds, mammals, and flowering plants appeared.	
E. The age of mammals	Mammals became the dominant form of land life about 60 million years ago. We still live in the age of mammals.	
F. Fossils	The fossil record shows that great changes in plant and animal populations have taken place. Many former species are extinct, and many new species have come into existence.	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
3. Theories About New Species		
A. Buffon and Lamarck	Both Buffon and Lamarck recognized that a "struggle for existence" exists in nature.	
B. Darwin and Wallace	At about the same time in the past century, Charles Darwin and Alfred Russel Wallace developed similar theories of natural selection.	
C. August Henry Weismann	Weismann performed experiments in heredity near the close of the past century, and his results led him to deny the inheritance of acquired characteristics.	
D. Hugo DeVries	At the turn of the century, DeVries proposed his mutation theory. His supposed evidences probably were not true mutations, but mutations do occur.	
4. Fitness and Survival	Competition exists everywhere in nature, and even involves the plants that grow in our gardens. The early death rate for many species of organisms is very high.	Competition Between Plants of Different Species (p. 536) Competition Between Plants of the Same Species (p. 536) Things To Do, #1, 2, 3, 4, and 5 (pp. 508-509)
A. The struggle for existence	In order to survive, organisms must avoid their natural enemies, and find sufficient food for themselves. A constant struggle for existence goes on in nature, and many individuals are eliminated.	
B. The survival of the fittest	Some members of a species are better adapted to survive than others. Because of the struggle for existence, the poorly adapted individuals are usually the first to die.	
C. Natural selection	Since the death rate is very high in nature due to the struggle for existence, the	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	well-adapted individuals tend to survive, and pass on the inheritable characters that made them well-adapted to future generations.	
D. Changes in populations	Fitness is determined by the nature of the environment. As the environment changes, fitness changes also. The amount of variation represented in a population is limited, and before the population can change beyond this limit, mutations must occur.	
5. The Distribution of Organisms A. The nature of dispersal	Dispersal is the process in which a species spreads out from its homeland over the surface of the earth. Ultimate distribution depends upon place of origin, means of dispersal, and ability to survive in the new areas that are invaded.	
B. Adaptation and dispersal	Some species are fitted to survive under a variety of conditions; others are not. Some species have never become dispersed beyond their homelands, while others have become widespread in their distribution.	

RELATED FILMS

	Min.		
Born to Die	10	B&W	FI
Environment and Survival: Life in a Trout Stream	10	Color	FAC
Evolution of the Vascular Plants: The Ferns	17	Color	EBF
How Living Things Change	11	Color	COR
Our Changing Earth	13	Color	FAC
Story in the Rocks	17	Color	Shell
The Strands Grow	15	Color	EBF
The Struggle for Life	10	B&W	FI

OVERVIEW AND RATIONALE

This chapter presents a brief account of plant and animal life in the past, beginning with a description of how fossils are formed. Then comes a discussion of various eras and periods in the geological past when invertebrates, fishes, amphibians, reptiles, and mammals were successively the dominant forms of life. This phase ends with recognition of the fact that many former species died out long ago, and that meanwhile, many new species came into existence.

The discourse then turns to a historical account of how some scientists such as Buffon, Lamarck, Darwin, Wallace, Weismann, and DeVries attempted to account for changes in plant and animal populations. The chapter then presents a modernized version of natural selection based upon variation, the struggle for existence, the survival of the fittest, and the action of heredity.

The chapter concludes with some observations on the present distribution of plants and animals. All organisms have a homeland or place of origin, from which they tend to become dispersed. But ways and means of achieving dispersal are not equally effective in all species. In addition, some species are adaptive and can survive under a variety of environmental circumstances, while other species do not succeed in maintaining themselves beyond the borders of their homelands.

GETTING STARTED

If you have some fossils available you can display them to the class and discuss how they probably were formed, and the types of past life they represent. An effective alternative is to visit a geological museum if such an institution is accessible to you. Either experience will serve to briefly introduce the history of past life that is presented in this chapter. Apt students may note that there has not been an age of insects or an age of birds, and the explanation is that so far as we know, neither group has ever been a dominant group.

Having considered the fossil record, the next question is: "What brought about the profound changes in past life, and how were they accomplished?" This takes you into a discussion of how the theory of natural selection was developed, and the nature of the theory itself. Do not overlook the point that natural selection and artificial selection are essentially the same, except that in the former case the nature of the environment determines survival, and in the latter case survival depends upon human decision. You will find a useful summarization of natural selection on page 503.

When you discuss geographical distribution you can direct attention to two important facts: a) species are not necessarily found in the communities to which they are best adapted, and b) some species can survive under a far greater range of environmental conditions than others.

CLASS NOTES

The Fossil Record (page 495) Some fossils are molds, and others are casts. Some are quite complete as to details of structure. Footprints, such as those left by some of the dinosaurs, are sometimes referred to as fossils.

The great majority of fossils have been formed in prehistoric shallow seas or swamps. Organisms that have no hard parts are not likely to become fossilized for obvious reasons. Plants and animals that live on dry land are sometimes fossilized when their remains are covered by wind-blown sediments.

The Age of Invertebrates extended through the early part of the Paleozoic Era. Fairly complex invertrebrates appear in some of the early Paleozoic rocks, and it may be inferred that they had precursors in Proterozoic time. Proterozoic evidences of life, however, are all of far simpler types. During the Age of Invertebrates animal life was probably confined to the seas.

In addition to the types mentioned in the text, invertebrates during this age included protozoa, echinoderms, brachiopods, and trilobites. All of the then-existing species are long since extinct, but most of them left descendants that have persisted into modern times. Incidentally, the trilobites were the first arthropods, and have since become extinct.

Some fishlike animals appeared in the Ordovician Period of the Paleozoic Era, and in the succeeding Silurian and Devonian Periods fish became a common and dominant form of sea life. Many of them were primitive types that died out millions of years ago.

The Age of Fishes is also notable because large numbers of land plants came into existence. The descendants of these land plants were widespread during the Age of Amphibians.

In the Mississippian and Pennsylvanian Periods of the Paleozoic Era many shallow seas and low-lying land areas were replaced by vast swamps. Back in the age of fishes, one type of fish apparently developed fin-limbs and lungs, and was able to survive out of water. This type is believed to have given rise to the amphibian line, which was obviously favored by the swamp environment, and expanded greatly.

This *Age of Amphibians* is also referred to as the *Coal Age*, because great forests of horsetails and club mosses existed on the swampy lowlands, and the products of this plant growth became buried in the mud and ooze, and later were compressed into coal.

The Permian Period closed out the Paleozoic Era, and was a time when the climate became less warm and a good deal more arid. The ancient swamps of the Coal Age disappeared, and swamp dwellers like the amphibians were no longer favored in much of the area where they formerly had been abundant.

From the old amphibian stock, however, a new line had arisen during the latter part of the Coal Age, which was destined to produce the dominant reptiles of the next era. Actually, the change from amphibian to reptile is not difficult to imagine; give an amphibian scales and plates, a type of egg that will develop out of water, and a few other changes and you have a reptile. The structural similarities of amphibians and reptiles are obvious, even in the case of modern types.

During the Mesozoic Era, which is referred to in the text as the *Age of Reptiles,* the climate became mild again, rains fell, and the primitive reptiles that had lived on from the preceding era gave rise to many descendants. Some of these new reptiles lived on land, some in the water, and some in the air. The dinosaurs, for example, were terrestrial animals which ranged in size from species no larger than a small bird to some that must have weighed about 50 tons. Some of these dinosaurs were plant eaters, but others obviously were carnivorous. In the waters were two other reptilian types, the ichthyosaurs and the plesiosaurs. Strange looking winged reptiles called pterodactyls could at least glide through the air.

Reptiles dominated the Mesozoic scene, but meanwhile three significant events occurred. Some time during this era the old amphibian-reptile stock gave rise to primitive mammals, which at first were small in size, and probably had a problem of survival because of their reptilian competition. In addition, some small, dinosaur-like reptiles became the first birds, which were odd creatures with teeth in their beaks and free claws on their wings. And finally, flowering plants came into being.

Why the reptiles came to the end of their reign in the closing centuries of the Mesozoic Era is not known. Perhaps they could not survive the onset of a colder climate that characterized the transition period. Perhaps during the winter season the small but warm-blooded mammals came out of their burrows and rock shelters to devour dormant reptiles and their eggs. Perhaps disease epidemics were responsible. At any rate, many of the reptilian types became extinct.

In the ensuing Cenozoic Era, which we have called the *Age of Mammals,* the mammalian group, freed from competition with the reptiles, soon expanded enormously. For millions of years this Cenozoic Era was relatively warm, but its latter portion has included the great Ice Age or Pleistocene Period. The earth emerged from this period about 50,000 years ago.

Theories About New Species (page 499) Earlier students of population changes, and especially Jean Baptiste Lamarck, had generally accepted the idea that variations produced by the use or disuse of parts could be inherited. Charles Darwin apparently sensed that some variations were not inherited, but was unable to distinguish between an inheritable category and a noninheritable category. In fact, Darwin had a theory called pangenesis which dealt with "gemmules" and a supposed mechanism for the inheritance of acquired characteristics.

In the closing decades of the nineteenth century, the discoveries of Weismann made it clear that acquired characteristics constituted the noninheritable category of individual differences or variations. But Weismann was a believer in natural selection, and he felt that the remaining category of inheritable variations was sufficient to account for the observed phenomena of changes in species.

The modern version of natural selection, then, is not identical with that of Darwin. Today, we know that mutations take place, and that they are primary factors in producing species changes. We are also aware that acquired characteristics have no permanent effect upon plant and animal populations.

The Distribution of Organisms (page 504) Various physical factors of the environment act as barriers to dispersal, and have greater impact on some organisms than they do on others. Thus, in the northern hemisphere the great ice sheets of the Pleistocene precluded the existence of many organisms in the northern area. Even when mild climates prevail, extremes of temperature, oceans, mountain ranges, deserts, extremes of pressure, the presence or absence of salt in water, prevailing winds, and various types of soil serve as barriers to the dispersal of many organisms.

Some organisms, of course, have better means of dispersal than others. For instance, spores and some seeds can be carried long distances by the wind, and many types of birds and insects can fly. Earthworms, on the other hand, can only move in a slow and laborious fashion. Once dispersal has been achieved, it remains to be seen whether the species can survive in the new communities it has invaded. Some of the simpler organisms that are relatively adaptive appear able to do so. But others of the less adaptive type may not survive under environmental conditions that differ markedly from the conditions in their homelands.

WORD MEANINGS (page 506)

1. Hard parts of plants and animals that have become part of a rock layer are known as (*c*) fossils.
2. In the following list, the period in which sponges, corals, mollusks, and similar animals were dominant was the (*d*) Age of Invertebrates.
3. In the following list, the only inheritable character would be the case in which (*b*) a plant mutation resulted in a new flower color.
4. The scientist who developed the mutation theory was (*d*) DeVries.
5. When fit individuals survive and pass on the characters that made them fit to their offspring, the process is called (*c*) natural selection.
6. In artificial selection, fitness is determined by (*a*) human choice.
7. When the members of a species move out of the homeland into new areas, the process is called (*b*) dispersal.

8. A species that can survive under a wide range of living conditions is said to be (*d*) adaptive.

SELF TEST (page 507)

1. False. Living things have existed on earth for hundreds of millions of years.
2. True
3. True
4. False. The first fossil birds had beaks bearing teeth.
5. True. But they did not prosper greatly until the Age of Reptiles ended.
6. False. Lamarck was the principal proponent of this idea.
7. True
8. True
9. False. DeVries studied evening primroses.
10. True
11. False. Surface soil is generally teeming with small forms of life.
12. True
13. False. There is no evidence that acquired characters can be inherited.
14. True
15. True
16. True
17. True
18. False. Place of origin is an important factor in determining geographical distribution, and especially so in the case of species that have limited ability to become dispersed.
19. False. Some species are far more adaptive than others.
20. True
21. False. Natural selection is believed to operate in all communities.
22. True

DISCUSSION QUESTIONS (page 508)

1. Fossils are being formed at the present time. The same processes of rock layer formation are taking place today that took place in the geological past, and the remains of plants and animals are still being buried under sediments.
2. The earliest known fossils appear in rocks that are more than 500 million years old. Life, however, may well have existed before this time.
3. According to the fossil record, the earliest forms of life lived in the water.
4. Reptiles are descended from amphibians. Birds are descended from reptiles. Mammals are descended from primitive ancestors of an amphibian-reptile type.
5. Coal deposits are formed in bogs or swamps. For this to happen, large numbers of plants must grow, die, and be buried under the mud and water. Then the pressure of sediments must bear down upon the plant remains to compress them into coal.
6. The first mammals appeared during the age of reptiles. They did not begin to dominate life on land until the Age of Reptiles had been concluded.
7. The struggle for existence was not an original idea with Charles Darwin. It had been mentioned by the ancients, and long afterward by Buffon and by Erasmus Darwin, who was Charles Darwin's grandfather. Buffon's philosophical ideas about evolution were, in fact, quite similar to the ideas that Charles Darwin incorporated in the theory of natural selection.
8. Weismann denied the inheritance of acquired characteristics because the results of his experiments with rats indicated that such characteristics were not passed on to the offspring.
9. The odd thing about DeVries' mutation theory was that he had based it upon the observation of supposed "mutations" that probably were not mutations at all. But subsequently it was discovered that mutations do occur in nature.
10. In nature there is constant competition for food and for living space. Organisms must obtain food in order to survive, and at the same time they must avoid destruction by their natural enemies. A green plant must have suitable living space and access to sunlight so that it can make foods. Even

so, this plant may be destroyed at any time by herbivorous animals.

11. Variation exists in all species, and mutations add new characters as time goes on. Competition in nature is severe, and only a small percentage of potential new individuals ever attain maturity. In the long run the individuals that do attain maturity are those best adapted to the existing conditions of life. These individuals reproduce, and pass on to their descendants the characteristics that made them well adapted insofar as these characteristics are hereditary.
12. Basically, the constant changes in communities are due to the fact that environments have become altered. Of course, some environments are more stable than others, but changes in the existing physical conditions are commonplace. In a changing environment, populations that once were favored may no longer be favored, and other populations that are well adapted to the new conditions of life may tend to flourish.
13. Bacteria, fungi, protozoa, and algae are likely to be very common in surface soils. This is particularly true of the bacteria and fungi. Various species of invertebrates are found there also, as well as some of the higher forms of animal life.
14. A struggle for existence is almost certain to take place because the potential rate of reproduction in many species is extremely high. Only a small percentage of the offspring that might be produced can possibly survive because there is not enough food and living space to accommodate all of them. Moreover, many organisms must eat other organisms if they are to obtain necessary foods.
15. In a state of nature, the conditions of the environment determine the characters that make an individual better able to survive.
16. For the steps in natural selection see the answer to item 11. The difference between this process and artificial selection is that in the latter man determines the characters that will be selected for survival.
17. Various factors are at work in dispersal. Spores and some seeds are carried by the winds. Aquatic plants and animals, as well as some seeds, may be carried by water currents. Many animals can swim, walk, or fly. Some species are carried about unintentionally by other species, as in the case of man transporting weed seeds in his plant produce. Even the force of gravity serves to disperse some organisms.
18. The present distribution of any organism depends upon all of the forces that have affected that organism in the past. These include place of origin, means of dispersal, the presence or absence of barriers to dispersal, and the ability of the organism to survive in communities it may invade.
19. Some species have become much more widely dispersed than others because a) they have effective means of dispersal, and b) they are able to survive under a wide range of environmental conditions.
20. When we say that a species is highly adaptive we mean that it can survive under a variety of living conditions. Thus, the house rat has demonstrated its ability to live in many parts of the world, under very different conditions of life, including extremes of climate. The house rat, of course, is omnivorous, and wherever there is organic material, a house rat is likely to find food supplies.

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CHAPTER 23 Man and the Balanced Community

THE CHAPTER AT A GLANCE

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
1. Introduction	In the course of time, man has moved into a great many natural communities. The native populations of a community constitute its wildlife. Such wildlife requires adequate food and cover for survival.	
2. Wildlife		
A. Effects of human activities upon wildlife.	When man moves into a community he removes trees, bushes, and native grasses to make room for crop plants. The way in which this is done determines how much natural food and cover will be destroyed. Some native populations may decline, but others may be able to maintain themselves.	
B. The importance of wildlife	Wildlife is a valuable asset in vacation areas. Various types of wildlife are also important as biological controls. In earlier times this was not fully realized, and a great deal of wildlife was needlessly destroyed.	
3. Conservation		
A. The meaning of conservation	Conservation involves the wise use of resources so that they may continue to exist.	
B. Forest resources	We use a wide variety of products that originate in the forests. Even chips and sawdust are used in industry.	
4. Forests of the World	Forests have been removed from much of Europe, Asia, and North America. The largest forest reserves are tropical forests of the East	Investigating Plant and Animal Fibers (p. 515) Things To Do, #1, 2, and 3 (p. 523)

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	Indies, Central America, and South America.	
A. Uses of wood pulp	Wood pulp is wood that has been shredded up. It contains cellulose from the walls of the plant cells. Wood pulp is used in making paper, rayon and other artificial fabrics, plastics, explosives, and many other things.	
B. Lumber and related products	Most of our annual tree crop is still used in making lumber, including plywood.	
5. Foods From Seas, Lakes, and Streams		
A. Ocean fisheries	Most of our marine fish come from the Atlantic and Pacific Oceans and the Gulf of Mexico.	
B. Freshwater fisheries	Our principal sources of freshwater fish are the Great Lakes, and streams of the Mississippi River System.	
C. Oysters and clams	Natural supplies of oysters have been greatly reduced, and many of them are now raised on "farms" in shallow sea water. Various edible clams are found along all of our ocean coasts.	
D. Lobsters, crabs, and shrimp	Supplies of these seafoods have also declined in recent years. Our large shrimp now come from deep waters in the West Indian area.	
6. Cultivated Plants	Men began to cultivate plants thousands of years ago. In modern times we have used our knowledge of heredity and selection to improve many varieties of these plants.	Soil Moisture and Plant Water Content (p. 538) Things To Do, #4 (p. 523)
A. Citrus fruits	These fruits had their origins in the Orient, and include the oranges, grape-	

TOPIC OUTLINE	IDEAS TO BE EMPHASIZED	RELATED INVESTIGATIONS AND ACTIVITIES
	fruits, and limes. The navel orange appeared as a mutation in recent times.	
B. Plants for many purposes	Scientists remain on the lookout for plant mutations that may prove to be useful. We protect our cultivated plants against weed competition, insect attacks, and plant diseases. From them we get foods, beverages, and many materials of commerce.	Things To Do, #5 (p. 523) Things To Do, #6 (p. 523)
7. Domesticated Animals	Men also began to raise animals centuries ago. Camels, horses, cattle, pigs, sheep, goats, pigeons, and chickens all represent very old domestications. We are in the process of domesticating various furbearers today, including foxes, minks, and chinchillas. We are also beginning to raise fish on a much larger scale.	Things To Do, #7 (p. 523) Temperature and Population Growth (p. 537)
8. Maintaining Balanced Communities	Problems of pest control are at a minimum in balanced communities. When man enters a community the old balance is destroyed; then the problem is to establish a new balance that includes man, his cultivated plants, and his domesticated animals.	Things To Do, #8 (p. 523)

RELATED FILMS

	Min.		
Conservation and the Balance in Nature	18	Color	IFB
Conservation of Natural Resources	11	B&W	EBF
Forest Smoke Chaser	27	Color	USDA
From Trees to Lumber	14	B&W	AFPI
Insect Foods	14	Color	Dowling
Life Cycle of a Fly	11	B&W Color	UW
Look to the Forest	22	B&W	IFB
Look to the Land	21	Color	EBF
The Prairie	18	Color	IFB
The Sea	26	B&W	EBF
Trees are a Crop	23	B&W	IFB
What is a Fish?	22	B&W Color	EBF
Wildlife Refuge	14	Color	IFB

OVERVIEW AND RATIONALE

In the early days of exploration and settlement, many biological resources were sadly depleted because their value was not fully recognized. Today, we appreciate the necessity of conserving such resources. Conservation measures are designed to perpetuate the resources so that they can be used and enjoyed today and at any future time. This is entirely possible, because biological resources are renewable: new plants and new animals are continually being produced.

Man has become a dominant member of many communities, and his presence has had inevitable effects upon wildlife, most of them being adverse. In clearing fields for crop production, sources of natural foods have been destroyed, and so has much of the cover that is indispensable to many kinds of wildlife. Where natural food sources and cover have been maintained, the adverse effects are minimized, and this is important because wildlife is a valuable asset in all communities, and especially so in the communities where recreation is big business. The maintenance of wildlife also is essential to many food chains, and to the survival of various biological controls that perform a welcome service in reducing the pest populations.

Forests are among our natural assets. Literally thousands of items that we use today have their origins in forest products. In recent years we have learned to use our forests in such a manner that new trees are always in production, and as a result, we are now producing more wood annually than we harvest. The largest remaining forest reserves, however, are the hardwood forests of the East Indies and tropical America. Basically, forest products are lumber and wood pulp. From wood pulp we make paper, plastics, and many other things.

We still obtain sizeable amounts of fish and shellfish from the oceans, the lakes, and large rivers, although supplies of some types have been greatly reduced in recent years. It has, of course, proved possible to raise oysters, and about half of the current oyster supply comes from "farms." But supplies of some other seafoods continue to dwindle.

Basic human foods come from plants that were brought under cultivation centuries ago. We use modern genetic methods to develop new and better varieties of these plants, from which we obtain not only foods, but beverages and many articles of commerce. Most of the animals that we raise have also been under domestication for thousands of years, but we are beginning to produce some new types that include certain furbearers and even some fish.

In the process of production, balanced communities are highly desirable, because in such communities the need for pest control is less urgent. After man has invaded a natural community it is not possible to maintain or restore the original balance. It is possible, however, to establish a new balance or near-balance that includes man, his cultivated plants, and his domesticated animals.

GETTING STARTED

One way to initiate this study is to conduct a field trip in a nearby area to discover the extent to which cover and natural foods are available to wildlife. This might be followed by a classroom discussion of the types of wildlife in the community, with attention to populations that appear to be maintaining themselves fairly well, and other populations that have obviously declined. Be sure the students understand that conservation is not designed to keep people from enjoying wildlife, but on the contrary, proposes to insure that there will be future supplies of wildlife.

From this introduction it is easy to go on and analyze the main types of biological production: the production that relates to forests, to aquatic communities, and to cultivated plants and domesticated animals. Most of the students probably will have little conception of the variety of things we obtain from forests alone. The study of plant and animal fibers described on page 515 will serve to make them aware of the extent to which we employ fibers in modern life.

In bringing this study to a logical conclusion, it is desirable to emphasize the importance of maintaining communities in a state of balance or near-balance. Our foods and many other materials of commerce come from biological sources, which are renewable sources if we deal with them wisely. In the balanced community, production goes along in an orderly fashion, and the need for pest control is minimal.

CLASS NOTES

The Forests (page 513) Forested areas are maintained today in national and state parks, and on private lands which in many cases are owned by corporations that use wood fiber in the manufacture of their products. Trees are harvested when they become mature, and before decay has set in to any great extent. At the same time, provision is made for the growth of new trees so that the forests will remain in production.

Destruction of forest trees is brought about mainly by fires, forest insects, and plant diseases. Many people will tell you that forest fires are usually ignited by lightning, but in fact, lightning only accounts for a small percentage of forest fires. Most forest fires result from human carelessness; the burning cigarette that is dropped on the dry forest floor or the camp fire that is left untended are typical examples. Efforts are made to control insects and diseases that attack forest trees, but the protection of large forested areas is expensive, and against some diseases such as chestnut blight, we have no effective measures to employ.

At present, the bulk of our lumber comes from western and southern forests. When we say that we are now producing more wood than we are harvesting, it does not mean that all types of trees are in good supply. The fact is, of course, that some kinds of lumber have become progressively harder to obtain. Meanwhile, however, better ways to process pulp, and to remove tars and resins have been devised, so that almost any kind of tree can now be used as a source of plant fiber. Incidentally, cotton fibers are essentially the same as wood fibers, since both of them are composed of cellulose.

Foods from Seas, Lakes, and Streams (page 515) Various species of edible clams exist along American coasts. Some of them live buried in the sand and mud of tide flats, and other types simply live on the bottom in shallow waters. Among them are species that have been exploited to the point that natural supplies are visibly failing. Conservation measures have been established to preserve some of these species.

The traditional American lobster, *Homarus americanus,* is native to the eastern coast of the United States and Canada. Two other lobster species are found in the coastal waters of Europe. These lobsters are sometimes confused with various species of sea crawfish, "rock lobsters," or langouste, which are similar in appearance, but lack the giant claws of the true lobsters. Sea crawfish are the source of so-called "lobster tails," which we import in quantity from South Africa.

As compared with marine fisheries, the freshwater sources are of minor importance. In a recent year, American fishermen took over 4 billion pounds of fish from the seas, and only about 10 million pounds from lakes and streams. The species taken in largest amounts (weight) included the tunas, salmons, herrings, and Pacific sardines, all of them coming from salt water.

Raising carp for food has been a European and Asiatic custom for many years. In recent times the practice of raising rainbow trout has been established in the United States, Japan, and Europe. The fish are quick-frozen, and some of those produced in Europe and Japan are shipped to American markets. We also import large quantities of other fish species.

Cultivated Plants (page 518) Plant cultivation may have begun over 10,000 years ago, both in the old world and in tropical America. The origins of some cultivated types are not known, since they came under man's dominion before historical records were kept. You may be interested, for example, in the case of Indian corn, which you can read about in various reference books. Presumably, it is of American origin, yet no American ancestor has been identified, and today we find ourselves wondering if such an ancestor has become extinct.

Domesticated Animals (page 519) Some domestications are also very old, and among them are types that have limited utility outside of their homelands, such as the llamas and alpacas of the Andean area in South America. The prehistoric Americans domesticated only the turkey and the muscovy duck. They also learned to cultivate a large number of plant species.

Students may be interested in the fact that within recent years silver fox, cross fox, platina fox, and silverblu minks have appeared as mutants on fur farms.

LABORATORY SUGGESTIONS

Investigating Plant and Animal Fibers (page 515, one period)

Materials: samples of fabrics, scissors, dissecting needles, blank slides, microscope.

Fibers that we use differ considerably. One of the great virtues of cotton fibers is that they have "kinks" in them, so that when they are twisted together they tend to "stay put." Yet fibers vary in different varieties of cotton, and some are much longer than others. Linen fibers are much longer than any of the cotton fibers.

ANALYSIS QUESTIONS (page 515)

1. Answers will vary, but some fibers will be longer, some will be more slender, some will be smooth, and some will break more readily than others.
2. All of the plant fibers are elongated, but some are much longer than others. All of them will burn, but not in the same manner. They vary as to elasticity, surface texture, and general appearance. Most of them are cylindrical, but cotton fibers are twisted.
3. You could tease apart the fibers of which the paper is composed. Then it would be simple to examine different types with the aid of a microscope, and compare them.

WORD MEANINGS (page 521)

1. cellulose—chemical substance from which paper is made.
2. cover—places where animals can find a refuge from their natural enemies.
3. biological control—species that destroys pests.
4. conservation—the wise use of natural resources.

5. wildlife—all of the organisms in a community that we do not raise.
6. fibers—materials used in making cloth.
7. oysters—animals that are now raised on "farms."
8. citrus—a type of fruit.

SELF TEST (page 521)

1. True
2. True
3. False. When the forest is destroyed their natural foods and cover generally are also destroyed.
4. True
5. False. A biological control feeds upon pest species.
6. False. It is made from thin slices of wood.
7. True
8. False. Pulp, for example, is used in the manufacture of many products.
9. False. Much of the northern forest and the central hardwood forest have been cleared away.
10. True
11. False. The great bulk of fish foods come from the seas.
12. True
13. False. We now raise about half of our oysters.
14. True
15. True
16. True
17. False. Citrus fruits are from the southeast Asian area.
18. False. It appeared as a mutation.
19. True. But generally speaking, the two trees must be closely related.
20. False. One characteristic of a satisfactory domesticated animal is that it does not compete directly with man for food.
21. True
22. True
23. False. Human populations are increasing steadily.

DISCUSSION QUESTIONS (page 522)

1. Cover provides places of refuge for many kinds of wildlife. Usually, this means refuge from natural enemies, but in some cases cover provides refuge from physical forces of the environment, such as the sun's rays, or extremes of temperature. Cover is important in the survival of many forms of wildlife, and so is the availability of a suitable food supply.
2. The preservation of wildlife is important because many of the organisms concerned are members of food chains, because some of them act as biological controls, and because some of them are valuable assets in recreation areas. The survival of wildlife is favored when natural foods and cover are maintained in the community.
3. Organisms that feed upon pests act as biological controls. Thus, a barn owl feeds upon mice, and native sparrows eat vast quantities of weed seeds.
4. Conservation involves the use of resources in such a manner that they are not destroyed, and will be available at any time in the foreseeable future.
5. Wood pulp is simply shredded wood from trees. It is important because it is a raw material of modern industry, from which such things as paper, wallboard, and plastics are made.
6. Cellulose is a material found in the cell walls of plants. We obtain it from wood fiber, and also from the fibers of some other plants such as cotton. It is used in making fabrics, plastics, explosives, and many other materials.
7. Men have learned to harvest trees in such a manner that new trees will soon occupy the same area and the forest will remain in production indefinitely. As a matter of fact, areas that have been cut over are sometimes reseeded.
8. Many and varied uses have been found for wood pulp. We use it in making acids, animal foods, alcohol, photographic film, soil conditioners, linoleum and soaps.
9. Ocean resources have always been important. Many nations turn to the sea for their fish, and Oriental people have

eaten certain seaweeds for centuries. Since human populations are increasing rapidly, it is natural to consider the seas as possible sources of more food and other materials of commerce.

10. Natural supplies of salmon and codfish have become depleted in recent years. This is in part because they have been overexploited. In the case of salmon, however, there is the added fact that some of them can no longer ascend the West Coast streams where they once spawned.
11. Many general uses have been found for plants in addition to providing a food supply. From trees we obtain lumber, plywood, other building materials including wallboard, turpentine, industrial alcohol, and many other items. In addition, useful adhesives are derived from some plants, such as the soybean. A number of plants are the sources of drugs that are used extensively in medicines, and some of them produce vegetable dyes that are used to color a variety of materials.
12. Soils and climate differ in various parts of the country. To be truly productive, ditions of growth that prevail in a given a plant must be adapted to the con- region. A cranberry plant will grow well in an acid bog, but in such a place corn plants would not prosper. Some plants will do well on a fairly dry soil, but others will not. Some plants require a much longer growing season than others do.
13. Plant mutations are important to man, because it is always possible that the mutant type will have qualities that will be especially desirable. These are not necessarily qualities that would aid a "wild" plant to survive, but they are qualities that plant producers are seeking for one reason or another.
14. We use our domesticated animals for a variety of purposes. From them we obtain foods, hides for leather, hair used in making fabrics, frying fats, eggs in the case of birds, and a good many by-products, including natural fertilizers. Some of the larger types serve as draft animals, and some of the smaller ones are sources of furs.
15. In the balanced community, no food group is unduly abundant. This applies to pests as well as the plants and animals that are useful to us. The control of pests, therefore, is less of a problem in balanced communities.
16. Man's presence in a community tends to disrupt the balance in nature, because man removes native plants, including trees, to make way for his crop plants. In addition, man brings to the community many species of plants and animals that were not previously represented there, and adjustments in populations must take place before anything approaching a new balance can be achieved.
17. It is possible for man to live in a balanced community. It is not the same kind of balance, of course, that existed before man appeared on the scene, because the new populations must include man, and the various plants and animals that he has brought with him.
18. It is an advantage to maintain balanced communities because in them pest control is not so much of a problem, and production will usually go along at a steady and dependable rate.

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BLOCK IV Laboratory Investigations

THE CHAPTER AT A GLANCE

ACTIVITY	PURPOSE	RELATED CHAPTERS
Growth of a Yeast Population (p. 525)	To study population growth and learn a technique for studying it in microorganisms	Chapter 18
The Life Cycle of a Mold (p. 526)	To study a mold life cycle, and learn a technique for raising molds	Chapter 18
Testing Seeds (p. 527)	To learn how to test the viability of seeds	Chapter 19
Investigating the Effect of Soaking on Seeds (p. 528)	To test the effect of soaking on the ability of seeds to sprout	Chapter 19
Seed Parts and Sprouting (p. 528)	To test the effect upon sprouting when certain parts of seeds are removed	Chapter 19
Regeneration in a Flatworm (p. 529)	To experiment with the ability of a planarian to regenerate	Chapter 20
Development of an Amphibian Embryo (p. 530)	To observe the development of amphibian eggs	Chapter 20
Development of a Chick Embryo (p. 531)	To study the early development of the chick embryo	Chapter 20
A Cellophane Model (p. 532)	To demonstrate the relationship of dominant and recessive genes	Chapter 21
Using Beans to Predict Genetic Proportions in Offspring (p. 532)	To learn a technique that can be used to predict the heredity in future generations	Chapter 21
Investigating Albino Corn (p. 533)	To study the heredity of albinism in the corn plant	Chapter 21
Study of a Human Pedigree (p. 534)	To learn how certain human traits are passed on from generation to generation	Chapter 21

ACTIVITY	PURPOSE	RELATED CHAPTERS
Competition Between Plants of Different Species (p. 536)	To observe the manner in which two species of plants compete with each other	Chapter 22
Competition Between Plants of the Same Species (p. 536)	To observe the manner in which plants of the same species compete with one another	Chapter 22
Temperature and Population Growth (p. 537)	To analyze the effects of varying temperatures on the growth of yeast colonies	Chapter 23
Soil Moisture and Plant Water Content (p. 538)	To discover the water content of various plant tissues	Chapter 23

RELATED FILMS

	Min.		
Echinoderms—Sea Stars and Their Relatives	16	Color	EBF
Extra Forest Dollars	16	Color	USFS
Fact or Fallacy	30	B&W	IU
Insects and Their Relatives	11	B&W Color	COR
It Runs in the Family	30	B&W	IU
Lifeblood of the Land	19	Color	USDA
Life Cycle of a Trout	11	B&W Color	UW
Life Cycle of the Frog	11	B&W Color	UW
Simple Plants: Algae and Fungi	13	B&W Color	COR
The Early Hunters	29	B&W	NCET
The Forest Grows	10	Color	EBF
This Vital Earth	10	B&W Color	EBF

OVERVIEW AND RATIONALE

This block of laboratory experiences is concerned with reproduction, development, heredity, competition, survival, and the effects of these factors upon the growth and decline of plant and animal populations.

The exercises on pages 525 and 526 throw further light upon the nature of life cycles and reproduction in yeasts and molds. At the same time, students can learn a technique that may be employed in determining the growth rate of a microorganism population in the case of the yeast cells. These experiences are followed by a study of various factors that affect the sprouting of seeds, which include an experiment in seed testing, an experiment on the relationship of soaking (in water) to seed sprouting, and an experiment designed to reveal the relative importance of various seed parts.

On page 529 an experiment on regeneration in a planarian is presented. This is followed by observations of the manner in which amphibian eggs develop, and embryo formation and development in a hen's egg.

The next group of demonstrations and experiments are concerned with the operation of hereditary mechanisms. They emphasize the manner in which opposed genes are paired, the effect of random crosses upon a population, the inheritance of a recessive characteristic (albinism) in a population, and the study of pedigrees.

The experiments described on pages 536 and 537 have to do with competition. They deal with competition between plants of different species, and competition among plants of the same species, and reveal various outcomes that are likely to result from such competition.

Finally, there are two experiments that serve to investigate the effects of temperature upon population growth, and the relationship of plant water content and soil moisture.

LABORATORY SUGGESTIONS

Growth of a Yeast Population (page 525, one-half period for preparation and several brief observations thereafter)

Materials: activated dry yeast, test tube, molasses or grape juice, cotton, blank slides, cover glasses, microscope.

If the directions given are followed carefully, the yeast population should soon show signs of increase, and this will be reflected in the counts made at the various intervals. The yeast cells presumably have been placed in a medium that supplies them with food, and their environmental conditions are otherwise favorable.

ANALYSIS QUESTIONS (page 526)

1. Answers will vary, but the pattern of growth probably will show a rapid increase in numbers, followed by a decline in numbers as conditions become less favorable due to crowding, accumulation of wastes, and exhaustion of the food supply.
2. Answers will vary, but in general, other microorganisms, given conditions favorable to them, will exhibit a similar pattern of population growth.
3. After a number of days have passed, the population growth should slow down; in fact, the population may begin to decline. Wastes have accumulated in the culture, making it an unfavorable environment, and food supplies have meanwhile been reduced.

The Life Cycle of a Mold (page 526, one period for preparation)

Materials: nutrient agar, test tubes, small jars, blank slides, cotton, mold culture, inoculating needle, millimeter ruler, sterilizing apparatus, microscope.

The sterilization procedures followed in this experiment are designed to limit the mold growths to the particular type that has been selected for study, insofar as this may be done. The nutrient agar solution is first prepared in test tubes, because this is a simple way to do it, and it is easy to keep the tubes sterilized. Nutrient agar solution is then poured from a test tube on to a microscope slide.

ANALYSIS QUESTIONS (page 527)

1. Answers will vary, but in general the students are likely to observe a few threadlike branches at first, and be able to see that these branches are made up of cells. In a day or two they may observe the growth of upright hyphae and the development of spore cases.
2. Answers will vary, but molds grow rapidly. A cycle would be the interval between the time when spores were used to inoculate a slide, and the time when the new mold produced mature spores.
3. Answers will vary, but actually, the time it takes to complete a life cycle is related to the prevailing temperature. This can be shown by preparing culture slides, inoculating them, and then keeping some of them at room temperature, while others are kept at both higher and lower temperatures.
4. Answers will vary, but molds grow a lot faster than people do.

Testing Seeds (page 527, one-half period for preparation)

Materials: seeds, paper toweling, pan or tray.

Even in the case of "good" seeds there are some that will not sprout. In certain samples you might find that few if any seeds will sprout, either because they are too old, or because they are not sufficiently mature. For example, the seeds might have been removed from the parent plant before they were fully developed. On the other hand, 90 percent of "good" seeds might be expected to sprout successfully.

ANALYSIS QUESTIONS (page 527)

1. Answers will vary.
2. Answers will vary.
3. If you used only one or two seeds, you might, by chance, select the one or two seeds in a mixed group that were either viable or not viable.

Investigating the Effect of Soaking on Seeds (page 528, one-half period for preparation)

Materials: seeds, 7 jars, 7 pans or trays.

Soaking the seeds should speed up the process of sprouting. But there is such a thing as soaking them too long, and this may affect the seeds in Groups 1 and 2, depending on the type they happen to be.

ANALYSIS QUESTIONS (page 528)

1. Answers will vary, but you can anticipate that some soaking of the seeds will favor rapid sprouting.
2. Answers will vary, but probably long soaking and very brief soaking will prove to be least effective.
3. Answers will vary, but are likely to be affirmative, based upon the results obtained with seeds in Groups 1 and 2.
4. Answers will vary, but in general, prior soaking will affect the sprouting rate of seeds to a variable degree. The way to find out is to perform similar tests upon the seeds of other species.

Seed Parts and Sprouting (page 528, one period for preparation)

Materials: lima bean seeds, 5 flats or planters, soil or vermiculite, scissors, forceps, scalpel.

As you probably can guess, the seed coats are not essential to the sprouting process. But the seed leaves are relatively important, because early growth and development depend upon the stored food they contain. The loss of one seed leaf may not be fatal to a seedling, but this loss reduces the chances for successful growth.

ANALYSIS QUESTIONS (page 528)

1. The portion of the embryo that becomes the stem and root is essential to sprouting. It lies along one margin between the seed leaves. A certain amount of stored food is also essential.
2. The seed coats and some of the stored food are dispensable.
3. Group 1 seeds were included in the study as a control, to make sure that these seeds would sprout under favorable conditions.
4. Seed parts might be lost through mechanical injury of one kind or another, or because insects and other animals eat parts of them.

Regeneration in a Flatworm (page 529, one-half period for preparation followed by several brief periods for observation)

Materials: several planarians, pan, fresh liver, razor blade, 2 petri dishes.

Planarians will not survive unless they are in cool, clear water. You will not get results in this experiment unless the directions are followed carefully, and the right sort of environment is provided for your specimens. The best results are likely to be obtained if you use the species *Planaria dorotocephala.*

ANALYSIS QUESTIONS (page 530)

1. If planarians have a favorable environment, head ends will regenerate tail portions, and tail ends will form new heads.
2. After a time the regenerated parts appear to be quite normal. The two new animals are, of course, smaller than the original animal.
3. Answers will vary, but the head ends will normally regenerate faster than the tail ends. The head ends are also more likely to survive.
4. Answers will vary. The obvious way to get more information is to perform other experiments. For example, several planarians might be cut into three or four approximately equal parts.
5. Answers will vary, but of course the human body does have some ability to regenerate, as evidenced by the fact that cuts, scratches, and broken bones will heal.

Development of an Amphibian Embryo (page 530, one-half period for preparation, and several observations thereafter)

Materials: amphibian eggs, culture bowls, scissors, forceps, test tube, cotton, hand lens, aquarium.

The first two divisions of a frog's egg cell are equal, and the result is the formation of four cells. After that, cleavage is unequal, with many small cells forming at one pole, and fewer large cells at the other. The pole with the small cells or micromeres is called the animal pole, and the pole with the large cells or macromeres is called the vegetal pole.

Cell division continues, and a cavity forms within the cell mass, which is now known as a blastula. The micromeres, which are dividing faster than the macromeres, spread out over most of the vegetal pole, so that there now are two cell layers constituting a gastrula. A third cell layer develops between the first two.

The embryo continues to grow, and begins to elongate as its internal systems develop. You can soon distinguish the head end from the tail end. You may note the appearance of eyes, a mouth, an anal opening, and external gills while the young tadpole is still within the egg membranes. The young tapdole bears cilia and moves about within the egg. These cilia are lost soon after hatching occurs.

ANALYSIS QUESTIONS (page 531)

1. Answers will vary, but any or all of the changes in the foregoing description may have been observed.
2. Answers will vary, but if the eggs came from the same egg mass, and were kept under comparable conditions, they should hatch at approximately the same time.
3. Temperature does affect the rate of development, but the evidences reported here will depend upon the type of experiment that has been devised and carried out.
4. Answers will vary, but of course development will be affected by many kinds of environmental changes. Various experiments might be planned to get evidences about such effects. You might, for instance, test whether the eggs will develop in a dilute saline solution.

Development of a Chick Embryo (page 531, six periods for preparation and observation)

Materials: incubator, fertile hen eggs, culture bowl, scissors, forceps, hand lens.

The two essentials in this study are the incubator and fertile hen eggs. The latter must be eggs from hens that are kept with roosters (many egg-producers keep the sexes in separate pens), and eggs that have not been kept in cold storage.

The egg as a whole does not divide. A circular patch of cells develops on the surface of the yolk, elongates as it increases in size, and develops ectoderm, mesoderm and endoderm layers. At 16 hours, the future body axis is clearly visible. At 24 hours the brain can be seen at the anterior end of the embryo. Behind the brain the two neural folds, flanked by four pairs of mesodermic somites, are in evidence. A notochord (beneath the surface) may be visible between the two neural folds.

At 33 hours a heart has been formed, and body systems are well along in their development. A vascular area is developing around the embryo proper on the surface of the yolk, and food from the yolk will soon be carried into the embryo by a system of blood vessels.

ANALYSIS QUESTIONS (page 531)

1. Answers will vary, but may include some of the items in the foregoing description of early development.
2. The students probably will see that the yolk diminishes in size as development proceeds. Stored food in the yolk is being used by the chick embryo.
3. Other portions of the egg are the shell, the shell membranes, and the white of the egg. The first two provide protection. The white of the egg serves to nourish the chick in the later stages of its development.
4. Answers will vary, but of course certain factors such as temperature and humidity changes can affect the development of the embryo, and even terminate its existence. A variety of experiments might be devised to check upon such effects.

A Cellophane Model (page 532, one-half period)

Materials: red, colorless, yellow, and blue cellophane, scissors.

When red is paired with colorless, its appearance is still red. When yellow is paired with blue, the resulting appearance is green. This is analogous to what happens in a) complete dominance, and b) incomplete dominance respectively.

ANALYSIS QUESTIONS (page 531)

1. The red cellophane is analogous to a dominant, because when it is paired with colorless, it appears as red.
2. When blue and yellow are paired, the result is an intermediate color, as it would be in a case of incomplete dominance.
3. As far as these models are concerned, it is easier to distinguish the hybrid in a case of incomplete dominance. This is also true in the case of organisms, because the hybrid "looks different."

Using Beans to Predict Genetic Proportions in Offspring (page 532, one period)

Materials: a sack containing plain beans, and a sack containing red beans.

The only factor that needs to be guarded in this test is that the two kinds of beans be of the same size. These beans can usually be found in any large market.

ANALYSIS QUESTIONS (page 533)

1. The results should approximate what occurs in nature: 25 percent pure dominant, 25 percent recessive, and 50 percent hybrid.
2. Three-fourths of the offspring would appear to be dominants, and one-fourth would be recessive. Of those that appeared to be dominants, two-thirds would actually be hybrids.
3. The model for a parent pure for a trait and a parent hybrid for that trait would have all plain beans in one sack, and half plain beans and half red beans in the other sack. The model for two parents pure for a trait would have either plain beans or red beans in both sacks.

Investigating Albino Corn (page 533, one period for preparation and several brief observations thereafter)

Materials: corn seed mixture of normal and albino characteristics in a ratio of 3:1, 4 planters, soil or vermiculite.

An albino corn plant is not prepared to survive. It has no chlorophyll, and it is unable to make foods. Therefore, it makes little difference whether such a plant is in a well lighted place or not. On the other hand, light is needed for chlorophyll production in normal plants, and these will appear to be albinos when grown in the dark.

ANALYSIS QUESTIONS (page 534)

1. Probably 25 percent of the seeds in the original mixture had two genes for albinism. Another 50 percent probably are hybrids, and carry one albino gene, while one-fourth of the seedlings are expected to be pure normal.
2. The normal seedlings grown in the dark did not turn green until they were brought into the light. The explanation is that light is necessary for the development of chlorophyll.
3. These seedlings begin to fail soon after they are placed in the dark. Their food-making process has been halted.
4. In the case of the plants grown in planter 3, the environment influenced the normal plants. While they grew in *darkness,* these plants (with normal heredity) appeared as albinos. Once they were moved into the light they developed chlorophyll and appeared normal. The environment had no apparent effect on the genetically albino plants; they remained albino in the light and in the darkness.
5. Albino plants are expected to die in a short time regardless of the light conditions. This is because they lack chlorophyll and cannot manufacture needed foods.

Study of a Human Pedigree (page 534, individual study)

Materials: notebook.

Students who engage in this activity should be advised not to study such traits as insanity, alcoholism, and some others. Queries about such matters are likely to be embarrassing. Have the students confine their inquiries to the kinds of traits listed on page 535. Students probably will be able to determine that a) presence of freckles is dominant over absence of freckles, b) dark hair is dominant over light hair, c) wavy hair is dominant over straight hair, d) free ear lobes are dominant over attached ear lobes, e) shortness is dominant over tallness, and f) ability to roll the tongue is dominant over lack of this ability.

ANALYSIS QUESTIONS (page 535)

1. Answers to these three questions will vary.
2. There should be some evidence of this type. If the trait is dominant about three-fourths of the individuals are likely to exhibit it.
3. If the genetic composition of the parents is known, it is possible to predict the probable appearance of the trait in a group of offspring.

Competition Between Plants of Different Species (page 536, one-half period for preparation, and several brief periods for observations)

Materials: three planters or flats with covers, two kinds of seeds, soil, balance.

Flats 1 and 2 have only one kind of seed in them, and the development of plants in these flats will indicate what you can expect these two species of plants to do under the conditions of growth you have established. These conditions must, of course, be as nearly the same for all of the flats as you can make them. In the third flat you have plants of two species in competition with each other. This third flat is the experimental flat, and the other two serve as controls.

ANALYSIS QUESTIONS (page 536)

1. Answers will vary, but there are likely to be some evidences of this nature. Compare the plants in flat 3 with plants of the same species that have grown in flats 1 and 2.

2. Answers will vary, but if the plants are grown out of doors, you might expect different results, because of different environmental conditions. The results of competition, however, should still be evident.
3. The plants will compete for sunlight, soil moisture, and the mineral compounds they absorb from the soil mixture.
4. The plants in flats 1 and 2 were certainly competing with one another. In the following experiment you will learn how to get evidences of this fact.

Competition Between Plants of the Same Species (page 536, one-half period for preparation, and several brief periods for observations)

Materials: planters, soil, seeds, balance.

In this case the plants are competing with other plants of the same species, and they are going to be too crowded in some of the planters. Be sure that all planters have equal amounts of light, warmth, and water. If any plants other than the corn or bean plants you are using should sprout (there may be some grass or weed seeds in the soil you use) remove these unwanted plants as soon as they appear.

ANALYSIS QUESTIONS (page 537)

1. Answers will vary, but growth and development will not be as successful in the more crowded planters.
2. Answers will vary; however, you may anticipate that some plants in a given flat will grow faster and become taller. Differences of this sort may be due to environment, or heredity, or both, and there is no easy way to be sure.
3. The seedlings in the first planter served as a control, since they were not particularly crowded.

Temperature and Population Growth (page 537, one period)

Materials: graph paper.

In this study students are supplied with the data in advance, and do not need to carry out the experiment. Students, are, however, called upon to explain what the data indicate.

ANALYSIS QUESTIONS (page 538)

1. The data clearly indicate that the yeast populations grew more rapidly at the higher temperature.
2. Answers will vary, but there are possible sources of errors. The counts might not have been made accurately. Another yeast culture might not give the same results. If any organisms other than yeasts got into some of the tubes, their presence may have affected the results.
3. Answers will vary, but in general should be affirmative.
4. So far as the students are concerned, it may or may not be a "typical" growth pattern. To be sure, it would be necessary to repeat the experiment with a number of yeast cultures, and compare the results.

Soil Moisture and Plant Water Content (page 538, one period)

Materials: Elodea, cactus, any garden plant, balance, drying oven, scalpel.

The plants used should be taken from their "normal environment" immediately before the tests are made. Samples need not be of the same size, since the results are obtained in percentages, but it will simplify matters to start out with wet samples that weigh about 100 units each.

ANALYSIS QUESTIONS (page 538)

1. Answers will vary.
2. Answers will vary.
3. Answers will vary. Actually, the findings probably would not be uniform for all plants that grow in a particular habitat.

WORD MEANINGS (page 542)

A

1. albino—organism lacking the ability to produce certain pigments

2. budding—process by which offspring appear as an outgrowth from the parent.
3. hybrid—individual with a dominant and recessive gene for a trait.
4. limiting factor—condition tending to slow down the population increase of organisms.
5. moss—green plant that produces spores
6. recessive—trait appearing in an offspring but hidden in its parents.
7. sediment—solid material carried in river water.
8. seed—container for an embryo plant.

B

1. competition—struggle between organisms for resources available in limited amounts.
2. cone-bearer—a seed producing plant.
3. fungus—nongreen plant that produces spores.
4. incomplete dominance—condition in which neither gene of a pair is dominant over the other.
5. incubator—apparatus used to keep fertile eggs at a proper temperature.
6. pedigree—chart of an individual's ancestry.
7. regeneration—process of replacing lost parts.

SELF TEST (page 542)

1. True
2. True
3. False. Molds produce spores, which are asexual in some cases, and sexual in others.
4. True
5. False. Neither mosses nor ferns produce seeds.
6. False. A spore is a single cell, and generally a small one.
7. False. This is an example of asexual reproduction; only one parent is involved.
8. False. Various species of lizards, crabs, and starfish can regenerate certain parts.
9. True. Certain planarians can reproduce in this manner.
10. True
11. False. Embryo is also used in referring to certain plant structures.
12. False. They usually breed during the warmer months of the year. Many of them breed in the spring.
13. True. The black areas are the developing animal poles.
14. False. The water supplies needed moisture to keep the eggs from drying out.
15. False. The hybrid has one dominant gene and one recessive gene for a given trait.
16. False. Each bean represents a gene.
17. True
18. False. In this analogy neither color is dominant.
19. False. The albino plant cannot produce foods.
20. True
21. True
22. False. Yeast cells reproduce more rapidly at 22°C than at 12°C.

DISCUSSION QUESTIONS (page 543)

1. A mature yeast cell forms buds, which become young yeast cells and also grow to maturity and produce buds of their own. Yeasts can also reproduce by spore formation, but the students may not be aware of this fact. Molds develop spore cases at the tips of their erect hyphae. Sometimes spore formation is preceded by gametic union of cells from two different strains of mold.
2. If the medium is not sterilized it may contain the spores of various unwanted species. If it is sterilized, such spores will be killed.
3. Spores aid certain species of organisms to survive in two general ways. An organism living under adverse circumstances may encyst, and form spores within the cyst. These spores are much more resistant than active cells. Other types of spores, produced

under normal environmental circumstances, are carried long distances by air currents, and serve to disperse the species, and extend its range into places where conditions for growth are favorable.

4. A spore is a single cell. A seed is a much more complex structure, being in reality a plant embryo that is composed of many cells that have already become somewhat differentiated.
5. This knowledge is of practical importance to farmers, who would not want to plant seeds that were only 50 percent viable. It is also of importance in various experiments you do in the laboratory, because you must have the knowledge in order to interpret results accurately.
6. In asexual reproduction such as simple fission, budding, some kinds of spore formation, and growth from parts, an offspring has only one parent. In sexual reproduction sex cells from male and female parents unite to form a fertilized egg cell from which the new individual develops.
7. Strong powers of regeneration aid in survival, because they enable organisms to replace lost parts. A starfish might be severely handicapped if it lost two arms, but since it can regenerate new arms, the handicap may be overcome.
8. A fertile egg cell is one that has been fertilized, and is capable of giving rise to a new individual.
9. The amphibian egg cell contains a quantity of stored food, which supports growth of the embryo that develops from it. This embryo obtains oxygen from the surrounding water. A chick embryo lives on stored food of the egg yolk and white. Air containing oxygen reaches this embryo through the shell and shell membranes.
10. Under natural conditions, this approximate temperature is maintained because the hen sits on the eggs and keeps them warmer than the surrounding air.
11. When a dominant gene is paired with an opposed gene, the offspring appears to be a dominant, although it is in fact a hybrid. The trait that is suppressed is represented in the recessive gene.
12. In the case of incomplete dominance, the hybrid is different in appearance from both the dominant and the recessive type. Thus, in four-o'clocks, red is the dominant type, and white the recessive, but the hybrids are pink.
13. In a case of simple dominance, the hybrid can only be identified by making one or more crosses with a known recessive. This is called a test cross.
14. Albinism is a serious condition in a green plant because such a plant is unable to make the foods it must have to survive.
15. Such seeds are obtained from populations in which albinism is known to exist. Mixtures of normal-albino seeds in a ratio of 3:1 are obtained by crossing hybrid plants that carry the albino trait. Albino seeds cannot be obtained from albino parents, because albino plants do not survive long enough to reproduce.
16. Chlorophyll production is related to the environment inasmuch as it does not develop in the absence of light. It is related to heredity, because genes that are responsible for its formation must be present.
17. If you find that a certain trait appears in a considerable number of related individuals, the probability is that this trait is dominant. If you find that it appears in only a few individuals, it is probably recessive. The situation in the case of man, however, is likely to be complicated by the fact that some traits are influenced by more than one pair of genes.
18. Plants compete with other plants for growing space, light, soil moisture, and soil minerals.

19. Animals compete with one another for living space, food, and survival. Thus, Species A may, in many cases, feed upon species B, C, and D. If species A is successful in obtaining food, it is at the expense of the other species.

20. The main factor that limits growth in many desert areas is, of course, lack of water. But other physical factors may also be limiting, as they are in any community. Some desert areas, for instance, are very cold in winter, and others are very hot. In a polar area the conspicuous limiting factor is low temperature, but again, it is not the only one. In the deep sea the most important limiting factor is the existence of enormous pressure, but there is also a lack of sunlight as well as a comparatively low temperature.

21. The human population growth pattern is similar to that of yeast cells in that it produces a rising curve, with each generation substantially larger than the last. The rate of increase through time, however, is not as great in the case of the human population.

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APPENDIX

LABORATORY ACTIVITIES

BLOCK I: The Simple and the Complex

CHAPTER 1. ENVIRONMENT AND LIFE

1. A Pond Culture (p. 11)
   —establishing a pond culture in the classroom.
2. Some Tests of Observations (p. 15)
   —demonstrating some limitations of the senses.
3. Some Experiments With Earthworms (p. 17)
   —testing the effect of certain environmental factors on blood vessel contraction rate.

CHAPTER 2. THE LIVING SUBSTANCE

1. Elodea Cells (p. 26)
   —observing *Elodea* leaf cells.
2. Testing for the Compounds of Protoplasm (p. 32)
   —testing for the presence of sugar, starch, protein, and fat in plant and animal tissues.
   —determining the percentage of water in plant tissues.
   —testing for the presence of an enzyme in various plant and animal tissues.

CHAPTER 3. CELLS IN ACTION

1. An Observation of Paramecium (p. 48)
   —observing the behavior of Paramecium.
2. A Single-celled Plant (p. 51)
   —observing a single-celled plant.
3. An Activity of Cell Membranes (p. 53)
   —testing the effect of certain environmental factors on cell membranes.

CHAPTER 4. THE ORGANISM

1. A Many-celled Alga (p. 61)
   —observing *Spirogyra* cells.
2. A Moss Plant (p. 65)
   —observing the parts of a moss plant.
3. Hydra: A Simple Animal (p. 67)
   —observing a living hydra.
4. An Earthworm (p. 71)
   —observing the external parts of a living earthworm.

CHAPTER 5. PLANT AND ANIMAL DIVERSITY

1. Individual Differences (p. 81)
   —demonstrating variation in the lengths of seeds, the sprouting of seeds, and in human reaction times.
2. Vascular Tissues (p. 99)
   —testing the effects of different concentrations of sugar and salt on the rise of liquid in a plant stem.

LABORATORY INVESTIGATIONS, BLOCK I

1. Reference Books and Guides (p. 105)
   —using reference books and simple classification keys.
2. Biological Equipment (p. 106)
   —using common laboratory instruments and glassware.
3. Collecting and Culturing (p. 108)
   —collecting and culturing specimens for study.
4. Preserving Specimens (p. 111)
   —preserving specimens in alcohol and formalin.
5. Raising Plants (p. 111)
   —sprouting seeds for classroom study.
6. Use of the Microscope (p. 112)
   —using a compound microscope.
7. Use of a Simple Projector (p. 113)
   —using a microprojector.
8. Temporary Microscope Mounts (p. 114)
   —preparing and staining cross sections of specimens.

9. Physical Factors of the Environment (p. 115)
   —testing the effect of sunlight on plant growth.
   —testing the effect of high temperature on life in a pond culture.
10. Carbon Compounds (p. 116)
    —demonstrating the presence of carbon in plant oil.
11. Radioactive Substances (p. 117)
    —using a Geiger counter to determine the presence of radioactivity.
12. Living Membranes (p. 118)
    —demonstrating osmosis with a semipermeable membrane and a carrot root.
13. Behavior of Paramecium (p. 121)
    —observing a reaction of paramecium to eosin.
    —observing fission in paramecium.
14. Stored Starch in Green Leaves (p. 122)
    —testing for the presence of starch in leaves.
15. Discharge of Oxygen by an *Elodea* Plant (p. 123)
    —collecting gas released by a plant underwater.
16. Plant Pigments (p. 124)
    —extracting and separating plant pigments using solvents.
17. Conjugation in Spirogyra (p. 125)
    —observing stages in spore formation using prepared slides.
18. Bread Mold (p. 126)
    —culturing and observing bread molds.
19. The Budding of Yeast Cells (p. 126)
    —observing reproduction of yeast cells.
20. Earthworms (p. 127)
    —observing behavior of a living earthworm.
    —dissecting an earthworm and observing its internal parts.
21. The Growth of Bacteria (p. 129)
    —culturing bacteria.
    —preparing and staining bacteria on microscope slides.
22. Bacteria and Molds (p. 129)
    —culturing bacteria and molds of decay.
23. Selecting a Community for Investigation (p. 131)
    —selecting a pond community for a detailed study.
24. Populations of the Community (p. 132)
    —observing the plants and animals of the study community.
25. The Roles of Community Members (p. 133)
    —determining food relationships within the study community.
26. Interaction Between Community Members (p. 134)
    —testing the effects of varying light on samples from the study community.
27. Effects of Temperature Change (p. 134)
    —testing the effects of varying temperature on samples from the study community.
28. Effects Caused by Freezing (p. 135)
    —testing the effect of freezing on a sample of the study community.
29. Effects Caused by Drying (p. 135)
    —testing the effect of drying on a sample from the study community.

BLOCK II: The Natural Community

CHAPTER 6. FOOD RESOURCES

1. Observing Root Hairs (p. 151)
   —observing radish plant root hairs.
2. Stem Types (p. 153)
   —observing stem cross sections.
3. Leaf Types and Structures (p. 155)
   —comparing the structure of different kinds of leaves.
   —observing the stomata of leaves.
4. Carbon Dioxide and Photosynthesis (p. 156)
   —testing to discover which surface of a leaf allows carbon dioxide to enter.

CHAPTER 7. COMMUNITY RELATIONSHIPS

1. Tapeworms and Roundworms (p. 165)
   —observing various worm parasites.
2. Laboratory Communities, (p. 168)
   —testing to discover how various organisms interact in a miniature community.

CHAPTER 8. PHYSICAL FACTORS AND LIFE

1. Temperature and the Growth of Bacteria (p. 182)
   —demonstrating an effect of temperature on the growth of a bacteria population.
2. Air and Plant Growth (p. 191)
   —testing the effect of oxygen deficiency and carbon dioxide deficiency on plant growth.

CHAPTER 9. SPECIAL ADAPTATIONS

1. Adaptations of a Snail (p. 204)
   —observing the effect of drying on a snail's behavior.
2. The Bird Skeleton (p. 212)
   —observing the structure of a bird skeleton.

CHAPTER 10. PATTERNS OF BEHAVIOR

1. Chemical Conditions of the Environment (p. 225)
   —testing the effects of varying salt concentrations on aquatic organisms.

CHAPTER 11. CHANGE AND DECAY

1. An Adult Insect (p. 243)
   —observing the parts of a grasshopper.
2. A Decaying Log (p. 245)
   —observing decay organisms in a piece of wood.

LABORATORY INVESTIGATIONS, BLOCK II

1. Setting up a Freshwater Aquarium (p. 254)
   —establishing a freshwater community in the classroom.
2. Other Types of Aquariums (p. 256)
   —establishing a saltwater aquarium.
3. A Bog Terrarium (p. 256)
   —establishing a bog terrarium.
4. A Woodland Terrarium (p. 257)
   —establishing a woodland terrarium.
5. A Desert Terrarium (p. 257)
   —establishing a desert terrarium.
6. The Rate of Photosynthesis (p. 258)
   —testing the effect of light intensity, carbon dioxide concentrations, and color of light on the rate of photosynthesis in an aquatic plant.
7. Loss of Water by Plants (p. 260)
   —demonstrating that water is lost through plant leaves.
8. Higher Plants (p. 261)
   —comparing the structures of different kinds of plants.
   —testing the effect of soil depth on seed sprouting.
   —observing plant parts used as food by man.
9. Population Changes (p. 262)
   —observing population changes in a miniature community.
10. Soil and Water (p. 263)
    —determining the amount of water that can be absorbed and retained by a soil sample.
    —determining the acid-alkaline condition of a soil sample.
11. Root Growth and Structure (p. 264)
    —demonstrating the effect of gravity on root growth.
    —demonstrating the effect of water on root growth.
    —comparing various types of roots.
12. Adaptations (p. 266)
    —observing the parts of a starfish.
    —observing the behavior of a fish.
13. Growth and Life Cycles (p. 268)
    —investigating the rate of growth in a plant, an animal, and a group of humans.
    —observing the stages in the life cycle of a fruit fly.
14. Mapping the Area (p. 271)
    —preparing a map of a land area to be studied in detail.
15. Studying Physical Factors of the Area (p. 271)

—investigating temperature, humidity, soil moisture, soil humus, soil pH, light intensity, and air movements in the study area.

16. Comparing Land and Water Environments (p. 274)
    —comparing the physical factors in a land and a water environment.
17. Studying Habitats (p. 275)
    —observing various habitats in the study area.
18. Surveying the Plants of a Land Community (p. 275)
    —collecting and preserving plant specimens.
19. Weed Density (p. 277)
    —determining the number of weeds growing in a sample of the study area.
20. Surveying the Animals of a Land Community (p. 277)
    —observing, collecting, and preserving animal specimens.
21. Common Pests (p. 278)
    —observing common pests in the study area.
22. Studying Soil Organisms (p. 278)
    —collecting and preserving organisms found in a small soil sample.
23. Investigating Interactions Among Organisms (p. 279)
    —observing root nodules and nitrogen-fixing bacteria.
    —testing soil for the presence of chemicals that inhibit seed sprouting.

BLOCK III: Man and His Environment

CHAPTER 12. THE HUMAN ORGANISM

1. A Cartilage Section (p. 291)
   —observing cartilage tissue.
2. Bone Structure (p. 294)
   —observing a bone and a bone cross section.
3. Muscle Functions (p. 296)
   —demonstrating how muscles work in opposed groups.
4. Circulation in a Fish Tail (p. 299)
   —observing blood flow in a fish tail.

CHAPTER 13. FOOD FOR MAN

1. Investigating Enzyme Action (p. 314)
   —demonstrating the action of pepsin on egg protein.
   —testing the effect of various factors on pepsin action.
2. Carbohydrate Digestion (p. 318)
   —demonstrating the effect of pancreatin on starch.

CHAPTER 14. ENERGY SUPPLY AND WASTE REMOVAL

1. Lung Tissues (p. 331)
   —observing a section of lung tissue
2. Breathing Rates (p. 333)
   —determining the effect of exercise on breathing rate.
3. Dissecting a Kidney (p. 334)
   —observing the parts of a kidney.

CHAPTER 15. BODY CONTROLS

1. The Animal Brain (p. 347)
   —observing the parts of a brain.
2. Eye Reflexes (p. 353)
   —observing the response of the iris to varying light intensity.
   —observing the eye-blink reflex.

CHAPTER 16. THE CONTROL OF DISEASES

1. Trichina Worms (p. 369)
   —observing trichina worm cysts in muscle tissue.
2. Flies and Germs (p. 372)
   —observing the wings and legs of a housefly.

CHAPTER 17. THE PUBLIC HEALTH

1. Microorganisms in Foods (p. 385)
   —testing the effect of various factors on the rate of food decay.
2. Antiseptics and Bacteria (p. 394)
   —testing the effect of antiseptics on decay bacteria.

LABORATORY INVESTIGATIONS, BLOCK III

1. The Internal Environment (p. 403)
   —testing the effect of exercise on muscle activity.
   —testing the effect of exercise on heart beat rate.
2. Digestive Organs and Enzymes (p. 405)
   —observing the digestive organs of a frog.
   —testing the effect of saliva on starch.
3. Vitamins (p. 407)
   —testing the effect of certain factors on vitamin C.
4. Respiration and Carbon Dioxide (p. 407)
   —testing various organisms for carbon dioxide production.
   —testing the effect of certain factors on carbon dioxide production by yeast cells.
5. Environment and Behavior (p. 410)
   —classifying types of behavior as voluntary and involuntary.
   —conditioning an animal.
   —testing the effect of past experience on feelings about certain words.
   —demonstrating trial and error learning of a maze.
   —investigating the effect of certain factors on memory.
6. Microorganisms (p. 414)
   —testing various objects for the presence of bacteria and fungi.

BLOCK IV: Production and Control

CHAPTER 18, REPRODUCTION AND POPULATIONS

1. Potential Population Increase (p. 434)
   —calculating the potential number of offspring from a corn plant and a single-celled organism.

CHAPTER 19, PLANT REPRODUCTION

1. Flower Structures (p. 446)
   —observing the parts of a flower.
   —observing pollen grains.
2. Seed Structure (p. 448)
   —observing the parts of a lima bean seed.

CHAPTER 20, ANIMAL REPRODUCTION

1. Crayfish Eggs (p. 461)
   —observing crayfish embyros.
2. Structure of an Egg (p. 467)
   —observing the parts of a hen's egg.

CHAPTER 21, INHERITANCE IN PLANTS AND ANIMALS

1. Some Observations of Variations (p. 480)
   —investigating variation in human hands, ear lobes, and leaves.
2. A Problem of Albinism (p. 487)
   —using colored beans to determine the proportions of various kinds of offspring expected to occur in populations.

CHAPTER 23, MAN AND THE BALANCED COMMUNITY

1. Investigating Plant and Animal Fibers (p. 515)
   —observing and testing some of the properties of fibers.

LABORATORY INVESTIGATIONS, BLOCK IV

1. Reproduction in Microorganisms (p. 525)
   —investigating population growth in a yeast culture.
   —culturing a mold and observing the stages in its life cycle.
2. Reproduction in Higher Plants (p. 527)
   —testing the percentage of sprouting in a sample of seeds.
   —investigating the effect of soaking on seed sprouting.
   —investigating the effect of removing various parts of a seed on sprouting.

3. Regeneration in Plants and Animals (p. 529)
   —investigating the ability of a flatworm to regenerate lost parts.
4. Embryo Development (p. 530)
   —observing stages in the development of an amphibian embryo.
   —observing stages in the development of a chick embryo.
5. Dominant and Recessive Genes (p. 531)
   —demonstrating the idea of dominance and recessiveness using a cellophane model.
   —using colored beans to predict the genetic proportions expected in offspring from various parent combinations.
   —testing the effect of light on the development of normal and albino seedlings.
   —investigating a single genetic trait in a human pedigree.
6. Competition Among Organisms (p. 535)
   —investigating competition between plants of different species.
   —investigating competition between plants of the same species.
7. Temperature and Population Growth p. 537)
   —graphing the data from observations of yeast cell growth at two different temperatures.
8. Soil Water and Plants (p. 538)
   —investigating the relationship between soil moisture and the water content of various plants.

LABORATORY MATERIALS

LIVING MATERIALS—ANIMAL

Crayfish, with eggs	1 per two students
Earthworms, small	1 per student
Frogs	1 per student
Fruit fly culture	
Hen eggs, fertile	1 per student
Hydra	1 per student
Paramecium culture	
Planaria	2 per student
Snails, aquatic	1 per student
Fish, small	1 per two students

LIVING MATERIALS—PLANT

Algae culture, green	
Corn, ears of seeds	1 per two students
Elodea	2 plants per student
Plants,	
Geranium	1 per six students
Moss	1 per student
Seeds,	
Lima bean	1 lb
Pea	1 lb
Corn	1 lb
Radish	1 lb
Spirogyra culture	
Tobacco seeds, albino-green	1 pkg per six students
Yeast, dry active	1 pkg per four students

PREPARED MICROSCOPE SLIDES

Cartilage tissue	1 per student
Hookworm, whole mount	1 per 2 students
Lung tissue	1 per student
Paramecium, fission	1 per student
Spirogyra, conjugating	1 per student
Tapeworm, segment	1 per two students
Trichina worm cysts in muscle	1 per student

PRESERVED SPECIMENS

Earthworm, large	1 per student
Grasshopper	1 per student
Starfish	1 per two students

PERMANENT EQUIPMENT

Aquarium, 2 to 4 gallon	
Balance, 0.1 gm sensitivity	1 per ten students
Bell jar and plate	
Bunsen burners	1 per two students
Dissecting trays	1 per two students
Flashlights, 2 cell	1 per two students
Geiger counter	
Magnifiers, low power	1 per student
Meter sticks	1 per two students
Microscopes, compound	1 per student
Oven	
Refrigerator	
Ring stands and rings	1 per two students
Trowels	1 per two students

GLASSWARE

Battery jar	1 per two students
Beakers,	
100 ml	1 per student
250 ml	1 per student
Dishes, culture (finger bowl)	1 per student
Graduated cylinder, 50 ml	1 per two students
Plates, glass (4 in. × 4 in.)	2 per student
Petri dishes, 15 mm × 100 mm	2 per student
Test tubes, pyrex	
4 inch	4 per student
6 inch	4 per student
Thistle tube	1 per two students
Vials, 2 to 4 dram	5 per student
Watch glasses	1 per student

SUPPLIES AND MATERIALS

Aluminum foil	10 ft
Blotting paper, white (12″ × 18″)	100 sheets
Cellophane,	
Red	1 roll

Clear	1 roll
Green	1 roll
Blue	1 roll
Yellow	1 roll
Cork borer	1 per four students
Cork stopper (for test tubes)	5 per student
Cotton, non-absorbent	1 lb
Cover glasses, microscope	5 per student
Dissecting needles	1 per student
Dissecting pins	6 per student
Flower pots, deep	1 per two students
Forceps	1 per two students
Graph paper, 8½″ × 11″	10 sheets per student
Gravel	50 lbs
Knife	1 per four students
Lens paper	10 packages
Medicine droppers	2 per student
Planters	1 per two students
Razor blades	1 per two students
Rule, 12″ with mm scale	1 per student
Sand	100 lbs
Scalpel	1 per two students
Scissors	1 per two students
Slides, microscope	2 per student
Steel wool	½ lb
Stopper, one-hole rubber (small)	1 per two students
Test tube holder	1 per student
Thermometer, wide range	1 per two students
Jars, widemouth with screw tops	2 per student

STAINS AND INDICATORS

Bromthymol blue	1 gm
Buiret reagent	1 pt
Congo red stain	10 gm
Eosin stain	10 gm
Fehling's solution, A and B	1 pt each
Gentian violet stain	10 gm
Iodine solution, Lugol's	1 pt
Litmus paper, red and blue	1 vial each per six students
Methylene blue stain	10 gm
Phenolphthalein solution	4 oz
pH paper, range 2-10	1 vial per six students
Sodium 2,6 dichlorobenzenone (Indophenol)	2 gm

CHEMICAL SUPPLIES

Agar, nutrient	1 lb
Alcohol, denatured	5 pts
Ascorbic acid, vitamin C	100 gm
Beef extract	4 oz
Calcium hydroxide	1 lb
Corn oil	1 pt
Formaldehyde, 40%	1 gal
Gelatine	4 oz
Glucose	1 lb
Hydrochloric acid	1 lb
Hydrogen peroxide, 3%	4 lbs
Pancreatin	4 oz
Paraffin	1 lb
Pepsin	4 oz
Peptone	4 oz
Petrolatum (petroleum jelly)	4 oz
Petroleum ether	2 pts
Soda lime	1 lb
Sodium chloride (table salt)	1 lb
Starch	1 lb
Sucrose (table sugar)	1 lb
Water, distilled	5 gal

SUPPLY HOUSES

Baltimore Biological Laboratory, Inc., 1640 Gorsuch Ave., Baltimore 18, Md.

Calbiochem, 3625 Medford Street, Los Angeles 63, Calif.

Cambosco Scientific Co., 37 Antwerp Street, Brighton 35, Mass.

Carolina Biological Supply Co., Burlington, N.C.

Central Scientific Co., 1700 N. Irving Park Road, Chicago 13, Ill.

Clay Adams, Inc., 141 E. 25th Street, New York 10

Clinton Misco Corp., P.O. Box 1005, Ann Arbor, Mich.

Faust Scientific Supply, Ltd., 5407 Schlueter Road, Madison 4, Wis.

General Biological Supply House, Inc., 8200 South Hoyne Ave., Chicago 20, Ill.

Macalaster Scientific Corp., 253 Norfolk Street, Cambridge 36, Mass.

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USDA	U.S. Dept. of Agriculture Motion Picture Service, Washington 25, D.C.
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